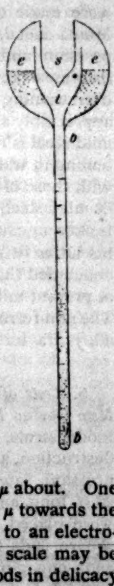
SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1911.

GENERAL PHYSICS.

1. *Simple Method of Measuring Nocturnal Radiation.* **A. K. Angström, Jr.** (Ann. d. Physik, 33. 4. pp. 845–849, Oct. 25, 1910.)—The author describes an apparatus devised by his father, the late Knut Ångström, for measuring the nocturnal radiation from the earth's surface. The essential part of the apparatus is shaped as shown in the Fig. It is made of glass. The outer concave surface of *s* is coated with lampblack. The apparatus is completely enclosed in a polished metal case, except for the concave surface *s*, which is exposed freely to the sky. It becomes cooled by radiation, and consequently ether distils from the surface *e* on to *s* and then trickles down into the graduated tube *b*. All air has been removed from the interior of the vessel. The length of the ether column which distils is proportional to the total loss of heat by radiation during the time the apparatus is exposed. Each instrument must be standardised by comparing its indications with a series of observations of radiation made with the standard Angström pyrheliometer. It is found that the constant of each instrument is practically independent of temperature. R. G. K. L.



2. *Micrometry by the Electrometer.* **J. Villey.** (Comptes Rendus, 151. pp. 716–717, Oct. 24, 1910.)—Two circular plates of 6·5 cm. radius are placed parallel and at a distance of 158 μ about. One plate is charged to a potential 176 volts and then moved by 1 μ towards the other plate; the potential of the latter rises, and if it be joined to an electrometer (made very sensitive) the deflection on the electrometer scale may be as much as 150 cm. One can thus surpass interference methods in delicacy in measuring small movements. P. E. S.

3. *Anomalous Behaviour of Balances.* **J. J. Manley.** (Roy. Soc., Phil. Trans. 210. pp. 887–415, Nov. 4, 1910.)—If observations are taken on a delicate balance for, say, 40 half-vibrations, the resting point is sometimes found to creep in one or other direction and then settle down. The author finds that most delicate balances are subject to this anomalous action which the experiments given show are due to (1) changes in the temperature of the neighbouring air, (2) certain inherent imperfections in the beam. The first class may be subdivided into: (*a*) Unequal change in temperature of the arms during loading. This is avoided by enclosing the beam in an extra case of metal and glass. (*b*) Radiant heat entering the balance case and acting unequally on the two arms. The best position for a balance in a room can be decided by trial. (*c*) Uniform change in temperature of the whole beam. To obtain accurate weighings it is necessarily to know the resting-point temperature-coefficient corresponding to the particular loading used. The second class of errors may be evaded by first counterpoising the object to be weighed and leaving the beam to oscillate for, say, 10 min. The beam becomes fatigued and then acts regularly. P. E. S.

4. *Elastic Breakdown of Non-ferrous Metals.* **C. A. M. Smith.** (Inst. of Metals, Journ. 2. pp. 151–209; Discussion and Correspondence, pp. 210–280, 1909. Mech. Eng. 24. pp. 548–546, Oct. 29, 1909. Abstract.)—The author describes an improved form of "sphingometer" designed to measure extensions in three planes inclined at 120°, and its application to the study of the elastic breakdown of non-ferrous metals, a continuation of the work on mild steel which appears to behave in accordance with Guest's law. Tests were made on solid bars of high-conductivity copper, arsenical copper, Muntz metal, and rolled Al, in tension, torsion, compression, combined compression and torsion, and combined tension and torsion. Overstraining increases the elastic limits of the three metals, but whereas the effect of overstraining in the case of Cu is removed by boiling in water, it is not appreciably affected in the case of Muntz metal and Al. The elastic limit of mild steel is raised by overstrain, and is still further increased by subsequent boiling in water. The specimens were fractured and the fractures compared with those of mild steel. Copper and Muntz metal fractures resemble those of mild steel, but rolled Al fractures in a manner suggestive of cast iron broken in compression. In torsion, Al fractures like mild steel, but whereas the latter twists through 8 or 4 revolutions, Al fails after 2 revs. The author concluded that ductile materials do not all possess similar properties, and that at present mild steel is the only suitable material for studies of elastic failure. The non-ferrous metals possess very indefinite yield-points, but copper and its alloys fracture in a manner suggestive of Guest's law. F. C. A. H. L.

5. *Tests of Nickel-Steel Models of Compression Members in Official Design of New Quebec Bridge.* (Eng. Record, 62. pp. 564–568, Nov. 19, 1910.)—The model struts, 16 in number, were mostly about ¼ full size, and were tested to destruction, about 20 sets of observations being taken on longitudinal compression, lateral deflection, &c. The heaviest of these models was about 20 ft. long, and withstood 2,800,000 lbs. without breaking. The test-pieces were placed horizontally in the machine, supported at their ends only, the square ends bearing on the vertical plate of the testing machine and the pin ends engaging horizontal pins of the proper diam. Four compressometers of the J. B. Johnson type, reading to 0·0001 in., one on each side of the test-

piece, were used to measure longitudinal compression, the mean of the four readings being taken. Tests on specimens of the nickel steel used gave 58,590–68,860 lbs. per sq. in. for elastic limit and 76,520–91,800 lbs. per sq. in. for ultimate strength, the highest results being obtained from the thinnest material. The elongation on 8 in. was 15·5 to 24·5 per cent., the reduction of area being 37·1 to 59·4 per cent. Tests on the models themselves showed elastic limits varying between 37,018 lbs. per sq. in. for long narrow members to 45,615 lbs. per sq. in. for shorter members, and ultimate strengths from 50,840 to 58,264 lbs. per sq. in. Failure occurred as a rule by the buckling of the webs, the rivet-heads holding the lattice bars being sheared off. Several of the heaviest sections were beyond the capacity of the machine (2,800,000 lbs.). In order to break them they were taken out and holes 2 to 4 in. diam. drilled through the webs. These, of course, failed at the weakest cross-section; most of the unweakened models failed near one end, usually the pin end. C. A. M. S.

6. *Strength of Guns and Cylinders.* **C. A. M. Smith.** (Engineering, 90. pp. 324–325, Sept. 2, 1910.)—The author has carried out numerous tests on mild steel subjected to compound stress. Various other investigators have worked in the same field, and have arrived at the same general conclusions. It has been found that when this material is subjected to a compound test of tension and torsion, or compression and torsion, elastic failure takes place when a certain shear stress has been reached. This stress is half the tensile stress at the elastic limit in the ordinary tension test. It is desired to show that this new fact affects the limiting stress for which guns and cylinders may be designed. Actual cases are given, and the numerical results tabulated and graphed. It is seen from the diagrams that the material will reach the stress at which elastic failure takes place by reason of the shear stress caused by the combination of the two principal stresses, and not the shear stress due to either principal stress considered separately. Hence the material will reach the point of elastic breakdown at a very much lower internal pressure than is usually assumed to be the case. Taking the case of a water main, it is shown that for a particular case there is about 50 per cent. difference between the real stress on the pipe material and that which is usually supposed to exist. The author has tested this theory of the failure of pipes and cylinders in a rough manner [Abstract No. 603 (1909)], and the fracture gives every indication of failure by reason of the shear stress when copper is used. Mild steel fails by reason of the max. shear stress. The author has attempted to burst a thick steel cylinder by means of internal pressure, and finds that he cannot do this. The hole enlarges, and the material appears to harden. It would seem, from these experiments, that the very great care which is taken to ensure the accuracy of bore of large guns is, to some extent, wasted. In conclusion, the stresses generated on firing guns are dealt with. **A. Morley** and **H. Phillips** (Ibid. p. 511, Oct. 7, 1910). A. W.

7. *Eccentrically-loaded Columns.* **W. E. Lilly.** (Inst. Civ. Engin., Proc. 181. pp. 460–477, 1909–1910.)—This paper shows the results of tests made at Trinity College, Dublin, to compare the experimental strengths with those given by the formulæ appropriate to the various cases. End loads were applied alternatively through rounded ends and through knife-edges in grooves of various eccentricities. A transverse load could also be applied centrally. Results are plotted with values of l/ρ as abscissæ and of p as ordinates;

l = length, ρ = radius of gyration of cross-section, p = crippling load. For long columns, central loading gives identical results with both methods of end loading, but for l/ρ less than 120 and greater than 40, the rounded ends become overstrained and flatten, giving too high values for p. For l/ρ less than 40 either end-loading gives the same failing load. For eccentric loads and l/ρ above 120 the breaking loads are nearly constant, showing that the modulus of elasticity governs failure, as assumed by Euler's formula. For l/ρ between 40 and 120 the ductility and elastic limit strength both exert an influence; the column is then permanently deformed. For l/ρ less than 40 direct flow occurs, and p rises to great values. For eccentric loads and specially large eccentricities p varies very little for a large range of l/ρ; failure is then largely due to bending. For small values of l/ρ, p tends to a definite limit with eccentric loads, thus enabling the constants for centrally loaded columns indirectly to be determined. The author derives the formulæ applied, and his results show that in nearly all cases the actual strength is above that given by theory, though it follows analogous laws. Finally, a general formula is deduced applicable to all conditions of dimensions and loading. C. A. M. S.

8. *Stresses in a Bar maintained in a strongly deflected Position.* **F. Kötter.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 42. pp. 895–922, 1910.)—Gustav Kirschoff was the first to define the conditions of stress for a strut fixed at one end and kept bent by a group of forces at the free end, the deflection being great. Kirschoff's investigation, so far as it concerns the form of the bent strut, confirms the theory of circular bending, but it gives anomalous results for the determination of the stresses set up, because of errors due to approximations made in the elastic equations: the molecules of the bent strut are treated as if it were straight, the components of stress due to deflection are treated as linear instead of quadratic functions of the thrust on the strut, and quantities of the third order are neglected in the equations for elastic potential. By considering the neglected quantities the author arrives at an accurate equation for the determination of the stresses. The case is investigated of a hollow circular strut, and, as is customary, the normal stress only is considered, the shear stress on vertical sections depending only on the area and not on the strength of the walls. The author claims that the value of his research lies in the fact that it enables us to determine the minimum permissible volume of material to bear a given stress.

C. A. M. S.

9. *Physical Interpretation of Hardness as measured by the Shore Scleroscope.* **R. H. Greaves.** (Inst. Civ. Engin., Proc. 181. pp. 478–489, 1909–1910.)—A. F. Shore, with his scleroscope, measures the hardness of materials by means of the rebound of a hammer with a rounded point, of known weight, and falling 25 cm. so as to hit the test-piece with a velocity of 222 cm. per sec. The degrees of hardness "H" are referred to a scale on which hard steel gives 100. Turner has, however, obtained some anomalous results; *e.g.*, rubber gives a hardness number of 28, and teak gives 12. A table of results for the metals obtained by the Shore, Turner, and Brinell methods shows considerable agreement, and indicates that the scleroscope does measure accurately a physical quantity which is comparable in materials of similar elastic-limit properties. If the velocity of approach is great, the scleroscope rebound is proportional to the square of "e," the coefficient of restitution between the steel hammer and the test-piece. Vincent found that,

for high velocities, $e = e_0 - m\mu$, where m = velocity of approach, μ = constant. These values of e (extrapolated to $\mu = 222$) are used by the author to calculate H, and are found to be proportional to H as observed on the scleroscope, showing that the latter gives a measure of e between the hammer B and the body A (called e_{AB}). Bodies with a high elastic limit recover quickly, and hence have a high value of e. If q_1 and q_2 are moduli of elasticity, and σ_1 and σ_2 are Poisson's ratios for A and B—

$$e_{AB}^2 = [e_{AA}^2(1 - \sigma_1^2)/q_1 + e_{BB}^2(1 - \sigma_2^2)/q_2]/[(1 - \sigma_1^2))/q_1 + (1 - \sigma_2^2)/q_2)],$$

or—

$$e_{AA}^2 = e_{AB}^2 - (\beta/\alpha)(e_{BB}^2 - e_{AB}^2).$$

For hard materials, the author demonstrates that the scleroscope verifies this law. The scleroscope values are not strictly comparable, for they measure e_{AB} and not e_{AA}, and Vincent has shown that whatever m may be, there is a max. velocity of rebound; the scleroscope, however, works with an arbitrary height. The standard scratch test used by Turner and Martens measures hardness in terms of (1) the elastic limit, allowing deformation; (2) the excess pressure above elastic limit to make standard deformation. (1) is measured by e_{AA}^2, (2) by PV/E, P = uniform pressure, V = volume deformed, E = energy of hammer at impact. Thence—

$$e_{AA}^2 = e_{AB}^2 - (\beta/a)(e_{BB}^2 - e_{AB}^2) - PV/E.$$

So that—

$$\text{H varies as } e_{AA}^2 + PV/E, \textit{ i.e.}, \text{ as } {}_{AB}^2 - (\beta/a)(e_{BB}^2 - e_{AB}^2).$$

Experiment shows that with the scleroscope, $e_{AB}^2 a$H and $(\beta/a)(e_{BB}^2 - e_{BA}^2)a$H. β and e_{BB} are constants, hence $H(a + K') = K$, K and K′ being constants, which is the equation to an hyperbola. The values of H obtained by the scleroscope and a are found when plotted to lie on the hyperbola $H(a - 0{\cdot}010) = 0{\cdot}68$. Only when a and H are so related do the Shore and scratch tests agree. Normal steel lies on the curve, but quenched steel lies above it, since a remains constant as H increases. Cold-rolling likewise destroys the relation by raising the hardness and elastic limit without altering Young's modulus. The shore test is found to check the Martel impact test (where there is no rebound). The Shore test gives a comparison of hardness for materials in one group such as cast and annealed metals; it bears the same relation to the scratch test, as the Martel does to the Brinell. The scleroscope measures hardness under instantaneous deformation as does the Martel, whilst the scratch and Brinell tests measure hardness under abrasion and plastic flow respectively. C. A. M. S.

10. *Elastic Properties of Platinum-Iridium Wire.* **L. P. Sieg.** (Phys. Rev. 31. pp. 421–462, Oct., 1910.)—Various tests were made on a 40 per cent. Pt-Ir wire to determine the influence of the previous treatment of the wire on the relation between torsional period and amplitude. The wire was first annealed at red heat and then tested for its period-amplitude characteristics with varying initial displacements; (*a*) when these initial amplitudes were gradually increased; (*b*) when they were similarly diminished. The series (*a*) showed that, for increasing initial amplitudes the range of period became greater; for any one amplitude the period increased, and the number of vibrations necessary for damping to 5° diminished. The logarithmic decrements, as functions of the amplitudes, increased with the amplitudes to a maximum. In the series (*b*), where the order of experiment was reversed,

the period-amplitude curves in passing over common ground agreed much more closely, the logarithmic decrement curves were very nearly in agreement with each other, and the number of vibrations necessary for damping to 5° now diminished with the initial amplitude. The annealed wire was lastly tested with a large amplitude, and then with various small amplitudes following each immediately on a large twist after annealing. The period-amplitude curves for the small amplitudes were remarkably close to each other, and were much lower than that for the large twist just mentioned; moreover, the curves for the small amplitudes, as they were increased, lay between the curves for the series (*a*) and (*b*) respectively. This indicated that the wire tends to recover after a short period of rest. The subsequent tests were made to find a preliminary treatment such that the wire should give similar results however tested. The wire was kept in constant vibration by means of a torsion head, and it was found that the periods increased rapidly at first, but after sufficient vibration they approached constant values. This vibration increased the damping period, and changed the form of the period-amplitude curves, the period keeping high down to lower amplitudes, and then falling off very rapidly. These changes disappeared after a continued vibration of 2¼ hours, the various functions reaching constant values. Keeping the load constant, the moment of inertia was varied, showing a small but definite effect on the period-amplitude curves similar to that produced by continued vibration. The statically determined coefficient of rigidity agreed with the kinetic determination for large amplitudes, but for small amplitudes the latter determination was larger than the former. For a given amplitude, the kinetically determined coefficient increased as the moment of inertia decreased. Lastly, the wire was annealed to a red heat and then vibrated through a large amplitude and subjected to electric currents which, as they were increased, exerted increasing restoring effects on the wire. This restoring power was greatly accelerated when the wire was heated to 275° C.
C. A. M. S.

11. ***Chemical and Physical Effects of Pressure Uniform in all Directions.*** **G. Spezia.** (Accad. Sci. Torino, Atti, 45. 11. pp. 335–348, 1909–1910.)—A mixture of finely-divided copper and silver, maintained for a month under a uniform pressure of 8000 atmos., does not show the slightest sign of any combination, and since the cupriferous deposits at Keveenaw Point contain copper and silver which have been in intimate contact under pressure for a very long time, the author considers that Spring's theory that high pressure is alone sufficient to produce combination of these metals, is inaccurate. Experiments with wax, which Spring found to flow like water under a pressure of 700 atmos., show that with a uniform pressure of 9900 atmos. for 12 days no liquefaction or semi-liquefaction takes place. The author criticises the conclusions of Spring and Kahlbaum [Abstracts Nos. 1242 and 2104 (1904)] that increase of pressure causes diminution in density of certain substances; the fact that the copper used by Kahlbaum changed its shape on compression proves that the pressure was not uniform, for a wax prism, compressed by the author in a water-bath, maintained its shape after subjection to a uniform pressure of 8200 atmos. for 24 hours.
W. H. St.

12. ***Coefficient of Friction.*** **W. Kaufmann.** (Deutsch. Phys. Gesell., Verh. 12. 20. pp. 797–801, Oct. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 21, 1910. Phys. Zeitschr. 11. pp. 985–987; Discussion, pp. 987–988, Nov. 1, 1910.)—The author has tested the accuracy of Coulomb's laws of friction, taking special precautions to avoid error due to contamination by dirt, &c., of the surfaces used. Mirror glass and Schott's glass have been employed, and the experiments were made by observing the angles at which slipping took place on inclined planes. The slider had three feet fitted with hemispherical caps, and the whole apparatus was placed in an air-tight case which could be filled with perfectly dry air. The results do not agree with Coulomb's. There is evidence that with the surfaces perfectly clean the slipping begins at a vanishingly small angle of inclination of the plane, and the motion of the slider is then uniform and not accelerated. With mirror glass the slider moved for an inclination of only 1·5° at a uniform speed of about 0·001 mm./sec. (The minimum angle for slipping is usually given as 15° to 20°.) Employing various inclinations of the plane, it is found that the friction is a continuous function of the velocity, and increases with the speed at first rapidly and then at a rate which gradually diminishes to zero. The constant final value of the friction is that usually measured. In the presence of moisture the friction follows Coulomb's laws. A. D. R.

13. *Friction in Small Air-pipes.* (Eng. Record, 62. p. 653, Dec. 3, 1910.)—The object of the investigation dealt with, which was carried out under the supervision of E. G. Harris, was to determine the value of c in the formula $f = clV^2/d^5r$, where f is the loss of pressure in lbs. per sq. in., l the length of the pipe in ft., V the volume in cub. ft. of air passing per sec., d the diam. of the pipe in inches, r is the ratio of the compression in atmos. Apparatus was arranged to supply air under pressures up to 10 atmos., to pipes of ½, ¾, 1, and 2 in. diam., and in lengths of 161 to 210 ft. A specially constructed drum for measuring air by orifice, according to the methods of Dudley, was used. This drum was supplied with orifices cut in No. 14 copper plate, and ranging from ½ to 8½ in. diam. Standard Crosby gauges were used to measure pressures, and also a specially designed differential gauge. Two tests were made on each size of pipe, one with 2 elbows, and the other with 16 or 18 elbows in the circuit. On each test 8 to 14 sets of readings were taken for as many pressure intensities. In the runs of 1-in. and 2-in. pipe, half was galvanised and half plain, while the ½-in. and ¾-in. sizes were new galvanised pipes. The observations on elbow resistance were not considered extensive enough to warrant the statement of any general conclusions, but it was noted that the results differed radically from data which have heretofore been published. In the formula given above, f was computed from the gauge readings, the value of r was taken as the average for the pipe, and V was determined by orifice measurement, applying Dudley's formula and coefficient. To facilitate the computation of c, results were plotted on a series of charts from which average values were taken. These results for small pipes seemed in accordance with the coefficients determined by French and German experimenters on pipes of larger diam., and hence were combined with them so that data on pipes of ½-in. to 12-in. diam. might be placed in a single table. In combining these results, coefficients for all the different diameters were plotted, and a straight-line average of the points was drawn. The equation of this line was found to be $c = 0{\cdot}076 - 0{\cdot}00188d$, where d is the pipe diam. in inches, and c the coefficient in the friction formula. A. W.

14. ***Influence of Local Heating on the Pressure sustained by a Body placed in a Current of Air.*** **A. Lafay.** (Comptes Rendus, 151. pp. 671–673,

Oct. 17, 1910.)—It was observed that local heating of a body exposed to a current of air influenced the distribution of pressure over the surface. An experimental cylinder 10 cm. in diam. was so constructed that a region of the surface 60° wide could be kept at a temperature of about 150° C. The cylinder was exposed to an air current of about 23 m. per sec., and the following observations were made. a is the angular distance of the point observed from the front of the cylinder, a_1, the position of the heated region; the pressures are given in mm. of water above atmospheric pressure.

Lower Surface of Cylinder a.	Pressures (Cylinder Cold).	Pressures (Heated Region).	
		$a_1 = -30°$ to $+30°$.	$a_1 = -90°$ to $-30°$.
−180°	−13	−13	−13
−120	−15	−15	−13
−100	−20	−18	−15
− 90	−27	−24	−19
− 80	−32	−28	−21
− 70	−30	−28	−22
− 60	−25	−23	−20
− 50	−15	−13	−12
− 40	0	0	+ 3
− 30	+15	+15	+17
− 20	+25	+25	+27
0	+34	+34	+35

It is suggested that possibly birds' wings may be the seat of thermal effects producing improved sustentation. C. A. B.

15. *Surface Tension by Plate Method.* **L. Grunmach.** (Deutsch. Phys. Gesell., Verh. 12. 20. pp. 847–859, Oct. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 21, 1910.)—A description of a piece of apparatus for determining surface tension by the rising of liquids in the space between two plates inclined at a small angle to each other. The vessel containing the liquid has plane glass sides. A plane glass plate dips into the liquid and the liquid rises between it and one of the sides, which it touches at a small angle. The surface tension of absolute alcohol is found to be 20·90 dynes per cm., and that of oleic acid 29·30 dynes per cm. T. P. B.

16. *Flow of Water through Rough-walled Capillary Tubes.* **E. Schnetzler.** (Deutsch. Phys. Gesell., Verh. 12. 20. pp. 817–821, Oct. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 22, 1910. Phys. Zeitschr. 11. pp. 1002–1004; Discussion, p. 1004, Nov. 1, 1910.)—Describes research on the flow of water through rough capillary tubes for a wide range of velocities. Both glass tubes and metal tubes were used, the former being roughened with hydrofluoric acid and the latter made as follows: Copper wire was wound closely on a steel wire; linen tape was then wound round this and the steel wire withdrawn, the spiral tube thus formed being secured inside a copper tube. The water was driven through the tubes by means of compressed air, pressures up to 250 atmos. being employed. The results obtained with the glass tubes show a marked departure from Poiseuille's law even with the smallest velocities. There is, as shown by the curve relating to pressure and volume discharged, an unmistakable critical velocity, and the constant (K) in the Reynolds' formula for the critical velocity $V = K\eta/sr$ varies for different tubes from 50 to 1200. With tubes of different length, but in other respects the same, interesting results were obtained. With long tubes the existence of a second critical velocity was shown, and the kink corresponding to this velocity in the pressure-volume curve is the more marked the longer the tube. Experiments on different sets of tubes of the same diameters but different degrees of roughness showed that this was always the case. For one capillary yet a third kink was found. These new critical points do not correspond to the beginning of a new type of flow; they appear to be places where the flow oscillates about a steady state. For greater velocities the previous steady state is restored, as appears from the continuity of the curve below and above the kink. A. W.

17. *Surface Energy and Surface Tension.* **J. E. Mills** and **D. MacRae.** (Amer. Chem. Soc., Journ. 32. pp. 1162–1176, Oct., 1910.)—The relation proposed by Whittaker [Abstract No. 1568 (1908)], that the surface energy of a liquid in contact with its own vapour at any temperature is proportional to the product of the internal latent heat and the absolute temperature, has been investigated by the authors, and the conclusion drawn that the relation is only approximately true. To the authors the relation suggests a division of the so-called surface energy of a liquid into two parts, one part due to the liquid surface and the other to the surface of the vapour over the liquid. A. F.

18. *Mechanical Vibration of Atoms.* **W. Sutherland.** (Phil. Mag. 20. pp. 657–660, Oct., 1910.)—On the basis of his theory of molecular and electrotonic potential energy, and of the electric origin of rigidity and cohesion, the author calculates the fundamental wave-lengths of vibration of the molecules of NaCl, KCl, KBr, and KI, and finds each about eight times that of the lowest wave-length experimentally determined by Rubens and Hollnagel [Abstract No. 552 (1910)] in the extreme infra-red. The fundamental wave-lengths of the molecules are obtained, in virtue of an acoustic analogy, by adding those of the constituent atoms, which is in agreement with the conclusions of former papers of the author's [Phil. Mag. (V.), vols. 30 and 32, and Abstract No. 37 (1902)]. These calculations suggest, therefore, that ordinary harmonic relations are to be expected amongst the wave-lengths of a substance in the extreme infra-red. G. W. DE T.

19. *Equation of Liquid and Gaseous Continuity.* **R. D. Kleeman.** (Phil. Mag. 20. pp. 665–689, Oct., 1910.)—Starting from the expression $(1/z^5)\phi_2(z/x_c, \beta)(\Sigma\sqrt{m_1})^2$, obtained in a previous paper [see Abstract No. 1199 (1910)], for the extra gravitational attraction between two molecules, the author obtains a more definite and fundamental expression than that derived from van der Waals' empirical equation of state, on the basis of an assumed distribution of the molecules at the corners of cubes, each of which has one boundary plane parallel to the surface of the liquid, and having edges of length x_a. This gives an expression for the intrinsic pressure in the form $K_2(\rho/m)^{7/3}(\Sigma\sqrt{m_1})^2$, where $m/\rho = x_a^3$, and K_2 is a constant for all liquids at corresponding states. Since ϕ_2 varies only slightly with the temperature, the same will apply to K_2, and the intrinsic pressure of any liquid can be approximately calculated by assuming it to be constant. Comparing the expression so obtained with one given in the previous paper, it is found that the intrinsic pressures of liquids in corresponding states are the same multiple of their critical pressures, and that this multiple is approximately

equal to the constant 54·9. By the aid of an expression for the internal latent heat of evaporation obtained in a previous paper, the intrinsic pressure P_m is found to be given by the equation $P_m = \rho L' K_3$, where K_3 is a constant for liquids in corresponding states, and L' is the internal heat of evaporation of the liquid into a vacuum. If the liquid be assumed continuous, this equation can be derived directly, K_3 being in that case equal to unity. This is experimentally confirmed, and leads to the conclusion that ϕ_2 is a function of the temperature only, and not of the distance between the molecules. Now let p be the external pressure, then the Boyle pressure will be the sum of p and P_m, since the latter represents the negative pressure due to the attraction of the molecules, so that the change of state equation may be written $p + K_2(1/vm)^{7/3}(\Sigma\sqrt{m_1})^2 = RT/mv$. According to van der Waals, v must be replaced by $v - b$, where b is the space occupied by the molecules; but b is not strictly a constant, for the apparent volume of two colliding molecules will be influenced by their mutual attraction and the attractions of surrounding molecules, and will therefore vary with the density, so that b must be a function of v and T, and the equation will assume the more general form $p + \psi_2(z/x_c, \beta)(1/vm)^{7/3}(\Sigma\sqrt{m_1})^2 = RT/m(v - \psi_3(v_1T_1)$, applicable to any liquid or gaseous state of matter. This leads to an isothermal curve of the well-known shape for a saturated vapour in contact with its liquid, and the practical non-realisability of the portion connecting the points corresponding to the saturated vapour and liquid respectively is shown to arise from the attraction of the matter of the containing vessel. The above equation is then transformed by the introduction of experimentally determined constants, and by writing $A - BT/T_2$ for K_3, and shown to represent experimental results, a large number of which are tabulated, better than the equation of van der Waals. Another form of the equation is then obtained by taking ϕ_2 a function of ρ instead of a function of T, which will evidently give similar results for the case of a saturated vapour in contact with its liquid, since the density is then a function of the temperature. The equation so obtained is found to be identical with one derived in an earlier paper [see Abstract No. 46 (1910)] from surface-tension considerations, and is tested for a number of liquids over considerable ranges of temperature. A further formula for the latent heat of internal evaporation is also obtained, and found to be identical with one derived by Dieterici [Abstract No. 825 (1908)], by aid of certain simplifying assumptions, from considerations of the kinetic equilibrium between the molecules shot out of the liquid into the surrounding vapour and the molecules returning from the vapour to the liquid. G. W. DE T.

20. *Molecular Attraction.* **J. E. Mills.** (Phil. Mag. 20. pp. 629–635, Oct., 1910.)—Referring to W. Sutherland's criticisms [see Abstract No. 1265 (1909)], the author maintains that they are not justified when his earlier papers are read in the light of the later ones. An error in the first of the series was corrected in the sixth [Abstract No. 1219 (1907). For his latest papers see Abstracts Nos. 765, 766 (1910).] The relation under discussion is $\lambda = \mu'(d^{\frac{1}{3}} - D^{\frac{1}{3}})$, where λ is the internal heat of vaporisation of 1 gm. of liquid, μ' is a constant, and d and D are the densities of the liquid and vapour respectively. The various assumptions made in deducing this relation are recapitulated and defended, and it is pointed out that D vanishes when the distance s between the molecules becomes infinite, leading to the simplified relation $\lambda_\infty s = \text{constant}$. That is to say, in any normal substance the internal heat given out as the molecules approach each other, multiplied by the distance apart of the molecules, is equal to a constant, and this statement

and the more general relation are true, because the molecular attraction varies inversely as the square of the distance apart of the attracting particles, and because the total amount of attractive force possessed by a molecule is a constant. G. W. DE T.

21. *Variations in the Vertical.* **J. E. Burbank.** (Amer. Journ. Sci. 30. pp. 323–334, Nov., 1910. Paper read before the Philosophical Soc. of Washington, Jan. 29, 1910.)—The paper deals with some slow-period changes of level of the piers on which the Omori horizontal pendulum seismograph has been mounted at the Cheltenham Magnetic Observatory. A comparison of the diurnal oscillation of level, and also the changes of level due to temperature-variations, shows that the magnitude and direction of these effects are to a large extent local. The passage of cyclonic areas had little direct influence in producing tilting by barometric loading, but the accompanying temperature-variations produced marked effects. Rainstorms also produced changes in level, especially when they occurred suddenly after long periods of dry weather. A. D. R.

22. *Application of the Principle of Archimedes to Exact Determination of Gas Densities.* **A. Jaquerod** and **M. Tourpaïan.** (Comptes Rendus, 151. pp. 666–668, Oct. 17, 1910.)—A cylindrical glass float of about 200 c.cm. was suspended from the beam of a balance and counterpoised. The float is enclosed in a glass flask slightly larger than the float itself. The flask ended above in a capillary tube, through which the suspension wire passed, and entrance was given to the gases by means of a tube sealed to the lower part of the flask. The whole apparatus was maintained at constant temperature by means of a bath of water. The carefully purified and dried gas is introduced into the apparatus at a rate of about 1 litre per hour; it displaces the air, and weighings can be carried out some hours after the commencement of the experiment. At the moment of weighing, the passage of the gas is stopped, except in the case of hydrogen. In this latter case the gas must be allowed to stream through; otherwise, owing to the rapid diffusion of air into the flask, there is an increase in the buoyancy. For the dynamic effect of the moving gas a correction must be introduced. The weight of the float *in vacuo* is necessary, and this was determined indirectly by means of hydrogen and of oxygen. Very concordant results were obtained. No further measurements are communicated. A. F.

23. *Four-dimensional Vector Analysis.* **G. N. Lewis.** (Amer. Acad., Proc. 46. No. 7. pp. 165–181, Oct., 1910. Contribution from Research Lab. of the Mass. Inst. of Technology, No. 58.)—A simple treatment of four-dimensional vector analysis and its application in electrical theory. In three-dimensional space we have vectors of no dimensions or scalars; vectors of one dimension, lines, &c.; vectors of two dimensions, planes, &c.; vectors of three dimensions, or pseudo-scalars. But since a plane uniquely determines the line normal to it, the two-dimensional vector is usually replaced by the one-dimensional, and so for tri-dimensional space we work with one class of vector only. But in four-dimensional space the various orders of vectors must be separately dealt with, viz., the 1-vector, 2-vector, and 3-vector; the 4-vector is a pseudo-scalar. E. H. B.

24. *Upper Air Research at Batavia.* **W. van Bemmelen** and **C. Braak.** (Konink. Akad. Wetensch. Amsterdam, Proc. 13. pp. 149–157, Sept. 1, 1910.)

—The paper gives a preliminary account of work done with kites, captive balloons and pilot balloons in 1909. *Temperature.*—The average fall of temperature for an increase of height of 100 m. was found to be (1) for the first 500 m., by captive balloon, 0·77° C.; by kite over land, 0·87°; by kite over sea, 0·91°; from 500–1000 m., by captive balloon, 0·57°; by kite over land, 0·72°; by kite over sea, 0·59°; from 1000–1400 m., by kite over land, 0·44°; by kite over sea, 0·71° C. The few observations at higher levels over the sea gave values less than 0·5°. Temperature inversion was often observed at about 1 km., commencing in the base of thin cumulus clouds. This effect was not found in dense cumuli. *Wind.*—The clear atmosphere in the early morning at Batavia is very favourable for work with pilot balloons. A summary of the wind's direction from kilometre to kilometre for the period Sept. to May clearly shows that the general air drift has easterly components up to the greatest heights attained (10–15 km.), but that during shorter or longer periods, the west monsoon thrusts itself below it. The east monsoon is one mighty current. At the level of separation between easterly currents above and westerly currents below, alto-cumuli may often be observed, which explains their general occurrence during the west monsoon and their absence during the east monsoon. The average height of alto-cumuli above Batavia is 5·4 km. (van der Stok and Figee). This is in good agreement with the average height of the separation of west and east currents found by the authors. On the first occasion of attaining a height of 18 km. a westerly wind was met with above 17 km., confirming a similar observation by Berson in East Africa. *Registering Balloon.*—Very few such ascents have been made hitherto. In the most successful a temperature of —42·6° C. was found at 11,548 m. The record shows no indication of being about to enter the so-called isothermal layer. A registering balloon ascent on May 19, 1910 (date of Halley's comet) showed no other remarkable feature than an inversion of temperature between 6 and 7 km. The balloon burst on reaching 7 km. R. G. K. L.

25. *Upper Air Research in Samoa.* **K. Wegener.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 101–129, 1910.)—The paper gives the results of observations with kites, made from Dec., 1908, to Nov., 1909; the results of simultaneous cloud observations are also discussed. After a brief description of the outfit of the station the results of the individual ascents are given. Temperature, percentage humidity, and wind direction and velocity are given for intervals of 500 m. Copious "remarks" are added. The results all show a surface "trade-wind" layer of height 1000 m. or 1200 m., in which the temperature gradient approaches very closely to the adiabatic, and sometimes exceeds it. Above this layer is a region of less constant wind direction, in which the most frequent direction is towards SW. Here the temperature gradient is much smaller. This layer extends to between 2000 m. and 4000 m. At higher levels, extending up to 10,000–15,000 m., the height of cirrus clouds, there is a layer which moves from between W. and NW. R. G. K. L.

26. *Meteorology: Isabnormals for Italy and their Relation to Pressure and Air Circulation.* **F. Eredia.** (Accad. Lincei, Atti, 19. pp. 401–407, Oct. 16, 1910.)—The normal temperature for places in different latitudes in the Northern and Southern Hemispheres having been determined (by the work of Hann and others) it becomes an interesting question to ascertain the influence of the local causes of heating and cooling, ocean currents, &c., in

causing deviations from these values in different places. The differences between the *normal* temperature corresponding to each region and the actually observed values constitute the *thermic anomaly* for that region. The *isabnormal* curves are thus obtained, and from the consideration of the orography of a region their course may be explained. Teisserenc de Bort and Sella have examined the distribution of these isabnormals, utilising the formulæ of Spitaler and Hann. Their work, however, being on too large a scale for the determination of local peculiarities of smaller areas, the author has entered into a more detailed examination for Italy. He has taken the corrected mean temperatures of 120 Italian towns for the period 1866–1906, using the formula adapted from that of Spitaler—

$$t_\phi = -2{\cdot}43 + 17{\cdot}61 \cos \phi + 7{\cdot}05 \cos 2\phi + 19{\cdot}29 n \cos 2\phi$$

(where ϕ is the latitude and n the relation between the distribution of land and water) for the months of Jan. and July, and also for the year. By comparison of the values thus calculated with those observed the values for the thermic anomaly were obtained : these were always *positive.* The author gives three maps of these curves, the first showing their course for Jan., the second for July, and the third their mean values for the whole year. The Jan. map shows that the max. deviation is to be found in the Ligurian Riviera, the minimum for a region near the centre of the valley of the Po. The July isabnormals differ considerably from these. In general, the coast regions show smaller values than those inland, but on the whole the July values are small, showing that the actual and theoretical distributions of temperature differ but little. The third map, that for the whole year, shows the greatest deviations as before for the Ligurian Riviera, high values generally for the coast regions, lower for the interior. For Sicily and the regions near the Ionian Sea the values are smaller and less well defined. For the relation between these isabnormals and the barometer, there is in general found an excess of temperature above the mean, either relative or absolute, with regard to other places of the same latitude, where there is to be found a closed minimum (cyclone) or bend in the isobars. High barometric readings are usually found with low temperatures. Comparison has been made with the relative pressure distribution given by Hann. It has been found that at all times of the year regions of minimum pressure correspond to high values of the thermic anomaly, and regions of max. pressure to low values. Thus the high values for Liguria correspond to the low pressure of that region, whilst the low thermic anomaly in the centre of the Po valley and Central Italy generally, corresponds to high pressure. The infrequency of cyclones in the valley of the Po is a feature of this district, accompanying the minimum values of the thermic anomaly. The influence of these phenomena on the direction and change of the winds, according to the well-known law of Dove, is next considered, and it is shown that the study of the thermic anomaly helps to interpret their direction in the lower strata of the atmosphere.

F. W. H.

27. *Solar Disturbances and Terrestrial Temperatures.* **W. J. Humphreys.** (Astrophys. Journ. 32. pp. 97–111, Sept., 1910.)—The sun being practically the source of all the radiation received by the earth, it is obvious that any important changes in its surface or envelopes which involve changes in its radiation must affect the terrestrial conditions. That the magnitude and frequency of auroral displays and magnetic disturbances follow closely upon corresponding changes in sun-spot activity appears to be well established. Many other phenomena, such as temperature, rainfall, plant growth, although evidently dependent on solar radiation, have so many intermediate relations that the direct influence is obscured to a certain extent. As being one of the phenomena capable of most accurate registration the author considers the variations of terrestrial temperature. Abbott and Fowle found that spot maxima are accompanied by temperature minima, and spot minima by temperature maxima, the average range being about 1° C. Although this may seem very small, it must be remembered that plant life is so sensitive that even such a small difference may retard the crop production by a whole year, as has been found in the sugar-cane industry in Mauritius. This decrease is much greater than is accounted for by the decrease of radiation directly from the sun-spot areas. There also appears to be evidence of a decrease of ultra-violet radiation during sun-spot maxima. The increase of auroral discharges tends to increase the proportion of ozone present in the upper atmosphere, especially in higher latitudes. C. P. B.

28. *Large Solar Prominences.* **F. Slocum.** (Astrophys. Journ. 32. pp. 125–129, Sept., 1910.)—Detailed descriptions, with photographic illustrations, of two remarkable prominences. One occurring on March 25, exhibited remarkable activity and only lasted for a very short time. It first appeared at 7h. 46·7m. G.M.T. March 24. Its shape was conical, with a height of about 46,500 km. At 2h. 54·9m. March 25 its height was 75,500 km., and at 4h. 14·7m. this had increased to 120,000 km., and ultimately the prominence matter attained a height of 290,500 km. By 7h. 48·8m. no trace of the eruption was visible. The other outburst occurred during the interval March 4 to April 28. When first seen it was just passing round the western edge of the sun. On March 16 it reappeared at the eastern limb, greater in extent and transformed in appearance. On March 18 the prominence matter reached over an arc of 47° on the sun's limb, a distance of about 572,000 km. Careful search on the flocculi plates of succeeding days failed to show any trace of the prominence as it traversed the disc. On April 18 visual observations in the lines Hα, Hβ, and D_3 showed that the shape of the prominence was in each case practically the same as that photographed in ultra-violet calcium light. C. P. B.

REFERENCES.

29. *Generalisation of the Relativity Principle and the Corresponding Mechanics.* **P. Frank** and **H. Rothe.** (Akad. Wiss. Wien, Sitz. Ber. 119. 2a. pp. 615–630 April, 1910.)—An endeavour to formulate a generalised mechanics of which the ordinary mechanics is a special case for which the longitudinal and transverse masses are each independent of the velocity. [See Abstract No. 790 (1910).]
E. H. B.

30. *Unital Derivation of the Transformation associated with the Relativity Principle.* **N. Umow.** (Phys. Zeitschr. 11. pp. 905–908, Oct. 15, 1910.)—The transformation of H. A. Lorentz which forms the chief object of the relativity theory is usually derived from a complex of assumptions and considerations. The present author here sets out to found it upon the single principle that in each of two worlds or systems characterised by x, y, z, t and x', y', z', t' phenomena of the same kind follow the same laws. The author then analytically obtains Lorentz's transformation on this basis. E. H. B.

31. *Relativity Theory: Four-dimensional Vector Analysis.* **A. Sommerfeld.** (Ann. d. Physik, 33. 4. pp. 649–689, Oct. 25, 1910.)—The second part of a theoretical and highly analytical discussion, the first part of which was noticed in Abstract No. 1215 (1910). It deals with four-dimensional space and is unsuitable for detailed abstraction. E. H. B.

32. *Relativity Principle.* **W. v. Ignatowsky.** (Deutsch. Phys. Gesell Verh. 12. 20. pp. 788–796, Oct. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 21, 1910. Phys. Zeitschr. 11. pp. 972–975; Discussion, pp. 975–976, Nov. 1, 1910.)—A semi-popular *résumé* of the relativity principle with special reference to the question of lengths and times in the two systems having a relative velocity. E. H. B.

33. *Dynamics of Moving Systems.* **J. Ishiwara.** (Mathematico-Physical Soc., Tōkyō, Proc. 5. 18. pp. 333–347, July, 1910.)—A mathematical discussion based on the conservation of energy and principle of least action. [See Abstract No. 998 (1905).] E. H. B.

34. *Motion of Rifle-shot in a Resisting Medium.* **S. Yokota.** (Mathematico-Physical Soc., Tōkyō, Proc. 5. 18. pp. 347–356, July, 1910.)—Obtains approximations for the drift of a projectile in a resisting medium owing to the couple exerted by that medium on the elongated shot and the consequent precession of the rotating body behaving as a gyroscope. E. H. B.

35. *Corpuscular Theory of the Aurora.* **C. Störmer.** (Comptes Rendus, 151. pp. 736–739, Oct. 24, 1910.)—The author discusses the question as to the situation of the zone of max. frequency of auroræ, if these phenomena are due to kathode rays, β-rays of radium, &c., and shows the agreement between theory and observation. A. D. R.

36. *Markings on Mars.* **J. H. Worthington.** (Nature, 85. p. 40, Nov. 10, 1910.)—During the 1909 opposition the writer was able to make numerous observations of the Martian features with the 24-in. refractor at the Lowell Observatory, Flagstaff, Arizona. An iris diaphragm was used over the objective, the best aperture being found to be about 18 in. Specially good views of the canals were obtained on Oct. 25, when the oases were also clearly defined. C. P. B.

37. *Rotation of Stars and Sun.* **A. Perot.** (Comptes Rendus, 151. pp. 848–850, Nov. 14, 1910.)—The author points out the necessity of care being taken when measuring the displacements of lines in the spectra of stars with extensive atmospheres, like the sun, to see that any possible effect due to the various media of different refraction through which the rays may have passed are eliminated before any conclusions as to radial velocity are deduced. C. P. B.

38. *Radial Velocity of ϕ Persei.* **H. Ludendorff.** (Astronom. Nachr. No. 4442. Nature, 84. p. 507, Oct. 20, 1910. Abstract.)—Recent photographs taken at Potsdam show additional faint lines identified with solar lines. These are being used for radial-velocity determinations in addition to the usual Hγ line, which in this star is apparently reversed. C. P. B.

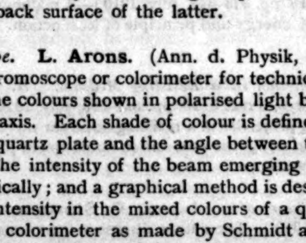
39. *Stellar Temperatures.* **J. Wilsing.** (Astrophys. Journ. 32. pp. 130–140, Sept., 1910.)—In continuation of a former memoir on the temperatures of 109 stars [Abstract No. 534 (1910)] an account is given of a second series of measures with certain added corrections based on a redetermination of the constant of the radiation of the lamp used as a secondary standard. The observations are being extended to all stars down to magnitude 4, north of the Equator. C. P. B.

LIGHT.

40. *A Goniometer-Refractometer.* **C. Chéneveau.** (Journ. de Physique, 9. pp. 828–829, Oct., 1910. Paper read before the Soc. franç. de Physique, April 15, 1910.)—Description of an instrument used for measuring indices of refraction and the dispersion of liquids. The principle of measurement with solid prisms appears to be that of the Abbe spectrometer; in the case of liquids a glass prism is immersed in the liquid, the rotation of the prism about a vertical axis gives a liquid prism of variable angle, and the deviation of the liquid is neutralised by that of the glass prism, reflection of the ray taking place at the back surface of the latter. G. E. A.

41. *A Chromoscope.* **L. Arons.** (Ann. d. Physik, 33. 4. pp. 799–832, Oct. 25, 1910.)—A chromoscope or colorimeter for technical uses is described which is based on the colours shown in polarised light by a quartz plate cut perpendicular to the axis. Each shade of colour is defined by two numbers, the thickness of the quartz plate and the angle between the principal planes of the two nicols. The intensity of the beam emerging from a quartz plate is considered theoretically; and a graphical method is described for obtaining the distribution of intensity in the mixed colours of a quartz plate between crossed nicols. The colorimeter as made by Schmidt and Haensch is then described, and examples are given of its use with quartz plates of thicknesses ¼, ½, 1, 2, 4, and 8 mm. and of the many shades of colour which can be obtained by means of the 63 combinations of these plates. G. E. A.

42. *Dark-field Illumination.* **F. Jentzsch.** (Deutsch. Phys. Gesell., Verh. 12. 22. pp. 975–991, Nov. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 22, 1910. Phys. Zeitschr. 11. pp. 993–1000; Discussion, pp. 1000–1001, Nov. 1, 1910.)—A concentric condenser is described which is suitable for dark-field illumination. The parallel rays from below (see Fig.) are reflected in the condenser from a silvered convex surface, and again at a silvered concave surface, and focus on the object. The two reflecting surfaces are concentric, their radii of curvature having a ratio of nearly 2·25 to 1. G. E. A.



43. *Combined Microscope and Ultramicroscope.* **C. Koristka.** (N. Cimento, 20. pp. 248–267, Oct., 1910.)—An apparatus is described which may be used both as a microscope and for the examination of ultramicroscopic objects. It has three means of illuminating a dark field: (1) An Abbe condenser; (2) a paraboloid condenser, and (3) a condenser with small apertures, suitable for use with or without oil immersion. The first method is applicable to the observation of the Brownian movement of particles and of bodies not requiring high magnification, the second to the examination of living bacteria, and the third to the study of ultramicroscopic objects. Means are provided for photographic reproduction of the latter, and with each method it is easy to change from illumination of a dark field to that of a light field, or *vice versâ*. Microphotographs of pleurosigma angulatum and ultramicrophotographs of human saliva are appended. W. H. Si.

44. *Filter for Ultra-violet Rays.* **H. Lehmann.** (Deutsch. Phys. Gesell., Verh. 12. 21. pp. 890–908, Nov. 15, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 22, 1910. Phys. Zeitschr. 11. pp. 1039–1047; Discussion, p. 1047, Nov. 15, 1910.)—The paper deals chiefly with an absorption filter containing nitrosodimethylanilin and copper sulphate in a flat, two-cell vessel made of blue uviol glass. The filter was used in conjunction with a quartz lamp, or other source of ultraviolet rays, and a quartz condenser lens for studying photoluminescence, fluorescence, and phosphorescence under the action of ultraviolet radiation. A large number of observations were made on chemicals, minerals, plant and animal matter, on which is based a system of luminescence analysis. In commercial chemicals pure substances exhibit little or no luminescence, whereas substances of second quality are strongly luminescent. This effect is confined mostly to single crystals or crystal conglomerates. The appearance and intensity of the luminescence depends on the method of preparation of the substance, different "makes" generally behaving differently. For further information see the original paper. G. E. A.

45. *Experiments on Refraction by Non-homogeneous Media.* **R. W. Wood.** (Phil. Mag. 20. pp. 712–714, Oct., 1910.)—That the apparent diam. of a body surrounded by a refracting atmosphere is slightly larger than its true diam. is well known. It can be shown in the following way: Make a small tank by cementing 5 glasses together with sealing-wax. Fill with melted gelatine. Mould a cylindrical hole with hemispherical bottom in the jelly by inserting a test-tube. When the jelly stiffens, pour hot water into the tube and withdraw it; pour a mixture of glycerine and chalk into the cavity till half full and fill up with milky water. The glycerine will gradually diffuse into the gelatine, increasing its index. After a few minutes the magnification can be seen through the side of the tank. On placing an arc light behind the tank and projecting an image of the cavity on ground glass, a bright ring of light appears surrounding its bottom, and eventually separating from it. Exner's experiments with pseudo-lenses made by immersing gelatine cylinders in water can be improved, and brought within the limits of a lecture-hour, by the use of glycerine. Soften gelatine in water, heat, filter, and pour into a test-tube. Boil down remainder to one-third bulk, add an equal quantity of glycerine, and pour into a second test-tube. After the jellies set, crack the tubes, heat momentarily, and push out the cylinders. Cut these into discs of different thicknesses with a warm knife, and mount the discs between warm thin glass plates. Immerse the gelatine-and-water cylinders in glycerine, and the glycerine jelly cylinders in cold water. After sufficient time for diffusion, the former will act as concave, and the latter as convex lenses;

since a jelly containing glycerine has a higher index than one containing water. Very sharp images can be obtained with such cylinders. Interesting refraction effects can be seen by nearly closing the ends of a tin pipe 8 m. long and 10 cm. in diam., with glass, inclining the tube and pouring in enough petrol to wet the entire bottom. Avoid proximity of flame. On tilting the tube back horizontally and placing the eye at one end near the bottom, the other end will appear elliptical, and external objects distorted.

A. E.

46. *Refraction and Magnetic Double Refraction of Solutions of Rare Earths.* **G. J. Elias.** (Deutsch. Phys. Gesell., Verh. 12. 22. pp. 955–962, Nov. 30, 1910. From the Bosscha Laborat.)—The anomalous dispersion of a solution of neodymium nitrate was investigated, by means of a Raps spectrometer, in the neighbourhood of the absorption band in the yellow. The anomaly is slight. Magnetic transverse double refraction was found with a solution of erbium nitrate placed between the poles of a Du Bois ring electromagnet. The case of a ray which does not pass through the solution in an exactly transverse direction is investigated by means of Lorentz's theory. [See also Abstracts Nos. 483 and 1212 (1909).] G. E. A.

47. *The Majorana-effect in rapidly alternating Magnetic Fields.* **L. Tieri.** (Accad. Lincei, Atti, 19. pp. 377–381, April 3, 1910. N. Cimento, 19. pp. 415–420, June, 1910.)—The explanation given by Schmauss of the magnetic double refraction of dialysed iron, according to which the phenomenon is due to the orientation which the particles in the colloidal solution assume in the magnetic field, has been completed by Cotton and Mouton [Abstract No. 2059 (1907)], who attribute the inversion of the refraction from positive to negative with increase of field to the existence of two kinds of granules in suspension, the larger having purely positive refraction and the smaller purely negative. This explanation leads to the belief that the phenomenon cannot be an instantaneous one, as is, for example, the Kerr-effect. A study is therefore made of magnetic double refraction in rapidly alternating fields. Preliminary experiments are made with samples 10 to 15 years old of Bravais' iron, which are examined in the field of an electromagnet between crossed nicols and a Babinet's compensator. Curves are drawn showing double refraction in wave-length displacement of the fringes as a function of the field, for the surface layers and also for the layers at the bottom, these latter being diluted with water to give them the same transparency. From the curves it appears that the superficial layers of such samples, which have been left for a long time in repose, are rich in negatively refracting granules, whilst the bottom layers are rich in positively refracting granules. To measure the rate at which the phenomenon is manifested the liquid is placed in a test-tube surrounded by a few turns of wire through which a discharge from a battery of Leyden jars is passed. The spark from the electrical machine illuminates the compensator and allows the displacement of the fringes to be observed. The time of the discharge is 17×10^{-7} sec. As a result, displacements of the fringes corresponding in value in the greatest instance to that produced by a field of 2800 gauss are observed for those samples which were shown in the preliminary experiment to contain the smaller, negatively-refracting particles. On the other hand, no displacement is to be observed for the samples containing the larger, positively-refracting particles. H. W. M.

48. *Dispersion of Light by Potassium Vapour.* **P. V. Bevan.** (Roy. Soc., Proc. Ser. A. 84. pp. 209–225, Sept. 15, 1910.)—Observations of the anomalous

dispersion of the vapour of potassium in the near neighbourhood of the principal series [see Abstract No. 1864 (1909)]. The results support the view that, at any rate, the principal series of lines are not due to different degrees of freedom of one and the same atom, but to different types of atom, whether formed by semi-permanent combinations of corpuscles with the normal atom (J. J. Thomson), or by the loss of differing numbers of electrons by the normal atom (R. W. Wood). E. C. C. B.

49. *Curved Photographic Plates.* **E. C. Pickering.** (Harvard Coll. Observatory Circ. No. 161. Nature, 85. p. 51, Nov. 10, 1910. Abstract.)—Numerous experiments have been made from time to time in the endeavour to obtain a larger field of good definition with the cameras employed in celestial photography. With a certain lens of 16 in. aperture the difference of focus between the edge and centre of plate is only 0·8 mm., but this is quite sufficient to mar the definition. By curving the plate to suit this change it was found possible to greatly improve matters, and the most convenient means for doing this was to exhaust the air from behind the photographic plate, thus causing it to become distorted in the required direction. C. P. B.

50. *Discontinuities in Light Emission.* **N. Campbell.** (Cambridge Phil. Soc., Proc. 15. pp. 518–525, Oct. 20, 1910.)—The present paper forms a second part to a previous one under the same title [see Abstract No. 678 (1910)]. Difficulties were encountered in the earlier work and the recent attempts to overcome them are here recorded, but are still unsuccessful. All hope of carrying out the main purpose of the research is thus abandoned. But it was thought that some results might be obtained by the fluctuation of two independent sources of light. The conclusion is reached that the experiments here recorded afford no grounds for distinguishing between the two theories. On the basis of a certain theory of the measurements, however, the observations lead to the estimate that the average number of electrons liberated by a single light-impulse is 8·1, which agrees well with the value deduced on other grounds, and also with that to be expected from Planck's theory of radiation, if the bundle-of-energy theory is correct. E. H. B.

51. *Method of Counting the Rulings of a Grating.* **G. W. C. Kaye.** (Phil. Mag. 20. pp. 714–717, Oct., 1910.)—The grating examined was a plane Rowland about 8 cm. long, on speculum metal, for which ignorance of the ruling temperature made the certified value (14,438 lines to the in.) not so certain as was required. The rulings were all the same length. The counting of the grating rulings was carried out with the aid of a projection microscope. Previously, close to one edge of the grating, short equidistant reference lines, ½ mm. long and 100 grating lines apart, were ruled by the laboratory dividing-engine. The grating was then mounted on the stage of the microscope, and an image of the edge of the grating thrown on the screen, where the grating lines appeared about 2 mm. apart, and about 150 of them were in focus in the field. On the screen was drawn a scale with divisions the same distance apart as the lines in the image of the grating. Thus, by slight sideways adjustment of the screen, 100 lines could be counted at a glance, and 1000 lines were counted in 4 min. The grating was found to contain 45,668 rulings, occupying a length of 8·08618 cm., giving a rate of 14,488·7 rulings to the in. at 16·0° C. Magnified photographs accompany the paper. The edge where the ruling diamond was set down is straight, while

the other where the diamond was lifted is irregular. It appears that the original flat surface of the speculum has been completely replaced by a succession of V-shaped furrows, with no intervening plane surface. A scratch across a corner has been almost removed by the rulings. With such a surface, the apparent width of the ruling should depend on the obliquity of illumination. A. E.

52. *Optical Difference-tones.* **H. Pettersson.** (Phys. Zeitschr. 11. pp. 909-910, Oct. 15, 1910.)—The experimental proof of the Doppler principle for light was first carried out by A. Bélopolsky [see Abstract No. 1145 (1907)]. His apparatus consisted of two systems of wheels each pair carrying eight radial mirrors. It seemed to the author that with this apparatus *light-beats* of a high frequency or *optical difference-tones* might be obtained. Thus if a very intense ray of homogenous light, say the green ray of a mercury lamp, is divided into two rays of equal intensity by a half-silvered plate and then each of these rays sent one way through a double-working rapidly-rotating apparatus of the Bélopolsky type; the frequency N of the one ray would be increased by ΔN, and that of the other decreased by the same amount, owing to the Doppler-effect. With the greatest velocity used by Bélopolsky ΔN would be 25×10^{-7} of N. Thus, a difference-tone of $2\Delta N$ or of wave-length about 110 cm. might be expected. This, if of sufficient energy, should be detectible as an electric wave by a suitable resonator and detector as used for wireless telegraphy. The author hopes to try this shortly.

E. H. B.

53. *The Echelette Grating for the Infra-red.* **R. W. Wood.** (Phil. Mag. 20. pp. 770-778, Oct., 1910.)—A bar to investigation of the distribution of intensity among spectra produced by a diffraction grating is the impossibility of determining the form of the ruled groove. It is difficult to learn anything from a microscopic examination. The author hit upon the idea of making gratings with grooves so large as to render the determination of their exact form, width, &c., easy; and then investigating the energy distribution by means of the long heat-waves discovered by Rubens. With the residual rays from quartz, and a grating having 1000 lines to the in., the ratio of wave-length to grating space is the same as with red light and a Rowland grating having 14,000 lines to the inch. After various trials, gratings were finally obtained which proved so efficient in the investigation of infra-red spectra that they seem worthy of a name of their own. They give far higher resolving powers in that region than have previously been available. They throw a large percentage of the energy into one or two spectra to the left of the central image, and show little or no trace of any energy to the right of it. With visible light they send the greater part into a group of spectra, say, from the 12th to the 16th order. They may thus be regarded as reflecting echelons, of comparatively small retardation, and the author proposes the name "echelette." These gratings are ruled on a sheet of polished copper plate (such as is used for the half-tone process), after it has been gold-plated and polished. Such plates give a much better optical surface than any the author was able to produce on a copper plate by grinding and polishing. The author remarks, that if any one knows a method of getting a flat optical surface on copper or gold, he will be very glad to hear of it. The copper plate is varnished with asphalt on the back to save gold. It is important to instruct the gilder to do as little buffing as possible. It is found that, even with the thinnest gold deposit, it is possible to rule very deep grooves without uncover-

ing the copper. The best gratings were made with Rowland's first machine and have 2062 or 962 lines to the inch. A carborundum crystal (angle 120°) is used for the ruling-point, and usually mounted so that one side of the groove is at 20° to the plate. The natural edges of the crystal rule a groove with optically perfect sides. Much depends on the tilt in ruling. *No metal is removed* in proper ruling, the groove being formed by compression of the metal. The best gratings show no trace of a central image; which indicates that the edges of the grooves are sharp, and that none of the original surface remains. In examining the surface microscopically two electric lamps are placed above the stage of the microscope, to right and left, so that the light is reflected vertically into the objective by the faces of the grooves. A red glass is placed before one lamp and a green before the other. The faces of the grooves appear in complementary colours, and if they do not meet at the top each pair of red-green strips is separated from the next by a dark line. If the grating when in use shows no central image, it may be assumed that the metal along the dark line has been forced up, and the original surface destroyed. Another method is to make a cast of the surface in celluloid, and cut sections with a microtome. Spectra obtained with the echelettes are described. The emission band of CO_2 from a Bunsen flame, hitherto only observed single, is easily resolved into three or four bands. Fuller discussion will appear in a later paper, and coloured plates in the new edition of "Physical Optics." The echelettes yield excellent replicas, which can be mounted on glass and gold-plated by kathodic discharge.

A. E.

54. *Diffraction of Single-pulse through a Slit on Kirchhoff's Theory.* **C. H. Wind.** (Konink. Akad. Wetensch. Amsterdam, Proc. 13. pp. 394–404, Oct. 27, 1910.)—In connection with the view that Röntgen rays are constituted of single-pulse disturbances, or nearly so, the author here treats mathematically the diffraction pattern for a single-pulse wave on passing through a slit on to a screen. The paper concludes with an elaborate plate showing the calculated distribution of intensity inside and outside the geometrical shadow, and the diagram applies to slits of different widths, for it is there shown as tapering, though the actual slits are supposed parallel. E. H. B.

55. *Optical Illusions and Double Reversals of Spectrum Lines.* **R. W. Wood.** (Phys. Zeitschr. 11. pp. 822–823, Oct. 1, 1910.)—The bright lines seen to divide the dark D lines on certain occasions appear also in photographs of the lines, but disappear in the photograph under enlargement, and in the spectroscope if the bright portions of the spectrum at the sides of the lines are cut off. The effect is ascribed to optical illusion, and it can be imitated. G. E. A.

56. *The Eye as an Electrical Organ.* **W. M. Thornton.** (Phil. Mag. 20. pp. 560–563, Oct., 1910.)—On the basis of measurements of the thickness of the various media of the human eye, and resistivity measurements of the media in the eye of a freshly killed ox, assumed to be the same as the corresponding ones in the human eye, the author shows from electromagnetic theory that the energy of light waves reaching the retina will be 0·0028 of that of the waves incident on the external surface. This reduction being independent of frequency, that is, of colour, the limitation of vision at the blue end of the spectrum must be due either to selective absorption or to photo-chemical inactivity of the visual yellow and purple in ultra-violet light. The fineness of the fibres in the reticulated optic nerve prevents "skin-effect," so that the electric current will be uniform over any cross-section. The object of this reticulation cannot be simply to permit the passage of light to the rods and cones, for a continuous layer of nerve fibre of the same thickness as the fibres would be transparent, though there might be selective absorption. An approximate estimate of the least current required for the sensation of light is obtained by considering the distance at which the sun would become invisible, in conjunction with the observed solar radiation, the result being a current $2{\cdot}87 \times 10^{-14}$ amp. in a fibre 0·0004 cm. in diam., or 28 microamps. per cm.^2 at right angles to the wave-front. This would give an energy absorption of $1{\cdot}31 \times 10^{-11}$ erg per cm. of fibre per sec., which, if each fibre conveys a separate stimulus, might be called the least specific stimulus required in the mental process of vision. The corresponding temperature-increase would not exceed 10^{-8} deg. C. per sec., so that the stimulus could hardly be a thermal one, but might exert "coherer" action in maintaining sensitiveness at the contact of the rods and cones with the retina. Comparison with Lodge's determination of minimum sensitiveness to sound shows that the eye should detect one-twentieth of the energy sensible to the ear. G. W. DE T.

57. *Diffraction of Polarised Light by very fine Dielectric Gratings.* **F. Braun.** (Phys. Zeitschr. 11. pp. 817–822, Oct. 1, 1910.)—The paper recounts optical experiments made with the microscopic test-object pleurosigma angulatum. Optically the shells act as if each consisted of two or three systems of gratings set at angles of 60 to each other. The distance between the bars of the gratings is about the length of a wave of red light. When the specimen is examined in a polarising microscope with the nicols crossed, a new system of fine lines appears which are parallel to the vibration direction of the polariser. Each aperture gives six spectra, for each of which the plane of polarisation is much rotated; no explanation was found for this rotation, which was noted to be greater in air than in immersion liquid, *i.e.*, it depends on the wave-length. The distance between the grating bars was determined as about 0·00060 mm.; accordingly the colour corresponding to a wave of this length should no longer give max. diffraction; it was found that when the incident vibrations in any spectrum were perpendicular to the grating bars the red of that spectrum became very feeble. The phenomenon is further discussed. G. E. A.

58. *Wave-length Measurements in the visible Region of the Arc Spectrum. III. Thulium.* **J. M. Eder** and **E. Valenta.** (Akad. Wiss. Wien, Sitz. Ber. 119. 2a. pp. 103–105, Feb., 1910.)—The authors have photographed the arc spectrum of Tm between the limits $\lambda = 6846$ and $\lambda = 5462$, using a sample which contained a considerable quantity of Er. On comparing the spectrum of this fraction with another containing little or no Er but some aldebaranium, certain weak lines were found common to both. These lines the authors attribute to a component of Tm, which they therefore consider not to be an element. E. C. C. B.

59. *Arc Spectrum of Iron Oxide.* **E. Domek.** (Akad. Wiss. Wien, Sitz. Ber. 119. 2a. pp. 437–452, March, 1910.)—Using flame arcs between iron poles and also between poles of magnetite in atmospheres of oxygen and of nitrogen, the author has found in the red and yellow parts of the arc spectrum of iron characteristic bands due to iron oxide. Photographs are given showing the difference between the spectra in the two gases. The wave-lengths of the components of the bands are tabulated. The first band begins at $\lambda = 5789{\cdot}74$ with a sharp edge, reaches its max. intensity about $\lambda = 5915$, and then diminishes gradually towards the edge of the second band. Below $\lambda = 5789{\cdot}74$ there lies another, weaker band which was not measured. The second band starts at $\lambda = 6180{\cdot}66$ with an equally sharp edge, reaches its max. intensity about $\lambda = 6230$, and then fades gradually towards the red. Measurements were made as far as $\lambda = 6350{\cdot}79$, but there are many groups of lines beyond this. The second band is inferior to the first in intensity and extent, and is also less characteristic in its construction. Both bands consist of a great number of lines and small bands, which lie very close to one another. The lines are very fine and in parts broadened and not sharp. The small bands have the same intensity for the whole width, and so no maximum; their edges are often not sharp. A. W.

60. *Absorption Spectrum of Iodine Vapour at High Temperatures.* **E. J. Evans.** (Astrophys. Journ. 32. pp. 1–16, July, 1910.)—The observations of the absorption were made with a silica tube heated electrically in a tube furnace, and the iodine was placed in a silica bulb immersed in an oil bath. This bulb was connected with the absorption tube, and the apparatus was so arranged that the bulb was the coolest part of the system. The pressure of the iodine vapour was calculated from the temperature of the oil bath, and the temperature of the absorption tube was measured by means of a Pt-Rh thermo-couple. It was found that the absorption lines disappear at some high temperature depending directly upon the pressure of the vapour. When the absorption vanishes there is always a very high percentage of dissociated molecules present, and it would seem likely that the absorption is due to the undissociated molecule, and that the monatomic molecules show no absorption within the visible region. It is not possible to account for the disappearance of absorption on the assumption that it is balanced by a corresponding emission, if it is assumed that the emission is a true temperature-effect. E. C. C. B.

61. *Spectral Series of Alkali Metals and Helium.* **R. T. Birge.** (Astrophys. Journ. 32. pp. 112–124, Sept., 1910.)—Recent investigations on the detection of members of the series spectra of various metals have furnished valuable material for testing the numerous formulæ put forward for representing spectral series [see Abstracts Nos. 821 (1909), 576 (1910)]. Using these values and recalculating the series, it is found that the formula propounded by Ritz, with three undetermined coefficients, will represent very closely the principal series of He, and of all the alkali metals except Cs. Sodium is represented with special accuracy. For sodium also the chief relationship between the principal series and the second subordinate series is accurately fulfilled. C. P. B.

62. *Absorption Spectra of Aniline and its Homologues as Vapours, as Liquids, and in Solution.* **J. E. Purvis.** (Chem. Soc., Journ. 97. pp. 1546–1559, Aug., 1910.)—The absorption spectra of aniline vapour shows about 83 bands between the limits $\lambda = 3005$ and $\lambda = 2717$, occurring chiefly as a series of doublets and triplets. None of the homologues of aniline show bands when in state of vapour; they all show, however, the characteristic broad absorption bands in alcoholic solution. Very thin layers of the pure liquids were also examined, but even at a thickness of 0·001 mm. no bands were observed.

The author explains these results by pointing out that the symmetrical orientation of the aniline molecule is absent in the homologues, and so in the case of the vapours the vibrations no longer exert selective absorption. In the solutions the solvent acts partly as a constraint on the vibrations of the molecules of the dissolved substance, partly as a barrier to the numbers of encounters, and partly as an absorbent of a portion of the radiant energy. The molecular vibrations then oscillate in a definite characteristic way. In the liquids the molecules are more closely packed, and they exert a greater tensional effect on each other, so that the restraining influences are more powerful. Nevertheless the differences observed in the general absorption show that, besides the weight of the molecules, the orientation is also an important factor in determining the general absorption as distinct from the selective. E. C. C. B.

63. *Absorption Spectra of Furan, Furfuraldehyde, Thiophen, and Pyrrole under different Conditions.* **J. E. Purvis.** (Chem. Soc., Journ. 97. pp. 1648–1659, Aug., 1910.)—The absorption of the four compounds has been observed in the state of vapour, as liquids, and in alcoholic solution. They all show bands in the state of vapour, and no selective absorption as liquids ; furfuraldehyde alone shows a band in alcoholic solution. A similar explanation as in the preceding Abstract is put forward by the author, who also points out that several factors have an influence on the absorption, as, for example, valency, mass, the nature of the ring system and its side chains, and the physical condition of the substance. E. C. C. B.

64. *Fluorescence and Band Spectra of Oxygen.* **W. Steubing.** (Ann. d. Physik, 33. 3. pp. 553–584, Sept. 22, 1910.)—A general discussion of the fluorescence and band spectra of oxygen, some of which the author has remeasured. He deals with them in relation to Stark's theory of electrons, and considers that the negative band spectrum and the first band spectrum (λ3888–λ2449) are due to the atom of oxygen, while the second band spectrum (λ1919–λ1831) is due to the molecule of oxygen. E. C. C. B.

65. *Three-fold Emission-spectra of Solid Aromatic Compounds.* **E. Goldstein.** (Phil. Mag. 20. pp. 619–622, Oct., 1910. Paper read before the British Assoc. at Winnipeg, Aug., 1909.)—When aromatic substances cooled in liquid air are subjected to kathode rays, three spectra are always evidenced in turn—the initial spectrum, the chief spectrum, and the solution spectrum. All three are very characteristic of any substance, but the second is particularly so, and it is possible to recognise at sight that of many compounds. The solution spectrum is a phosphorescent one, and may be observed some minutes after the kathode rays have been cut off. This spectrum is the most delicate test imaginable, as it is possible, for example, to recognise the presence of less than one hundred-thousandth part of naphthalene in methyl benzoate. So delicate is the test that the author has never been able to prepare or obtain a pure compound in the sense that it does not show the solution spectra of some impurity. E. C. C. B.

66. *Duration of Emission of Spectral Rays by Magnesium Vapour in the Electric Spark.* **G. A. Hemsalech.** (Comptes Rendus, 151. pp. 668–671, Oct. 17, 1910.)—Continuing his researches on the duration of the luminous vibrations of metallic vapours [Abstract No. 1488 (1910)], the author has investigated the relative duration of the rays of Mg, using the method of the

air-blast as previously described. Besides the spark rays there are the two series of triplets and the nebulous series. For the triplets and the nebulous series the coefficients of increase of duration in passing from a small to a large capacity are approximately equal for each of the rays of the same group. The rays of the nebulous series are, however, more sensible to variations of the capacity used than are the triplets. The spark rays have a much smaller duration with respect to their intensities than the rays of the triplets, a fact previously observed by Schenck and by Milner. If impurities are present, such as Ca, Fe, or Mn, it is generally found that the rays due to these have so abnormal a duration with respect to their intensities that they are easily identified. This may be utilised in the analysis of bodies containing unknown impurities. A. W.

67. *Effect of Magnetic Field on Duration of Spectral Rays.* **G. A. Hemsalech.** (Comptes Rendus, 151. pp. 750–752, Oct. 31, 1910.)—Using the method already described [Abstracts Nos. 1140 (1908), 1433 (1910)], an iron spark was subjected to a field of about 6000 c.g.s. units. It was found that the duration of nearly all the rays is diminished, and the intensity of the action on the different rays seems to be selective. In the immediate neighbourhood of the electrode, however, owing to secondary actions, all the rays have a greater duration. It does not follow that the observed modifications are due to a direct action of the magnetic field on the luminous vibrations. A. W.

68. *Secondary Wave-length Standards in Iron Arc Spectrum.* **H. Kayser, C. Fabry,** and **J. S. Ames.** (Astrophys. Journ. 32. pp. 215–217, Oct., 1910.)—At the fourth meeting of the International Union for co-operation in solar research held at Mount Wilson during Sept., 1910, it was agreed to establish as secondary standards of wave-length the means of the values obtained by three independent observers of certain lines in the arc spectrum of iron. These observers were Fabry and Buisson at Marseilles, Eversheim at Bonn, and Pfund at Baltimore. The list now published is to be distinguished by the symbol I.A., and includes 49 lines between the limits λ4282·408 to λ6494·993. C. P. B.

69. *Tertiary Standards of Wave-length in Iron Arc Spectrum.* **H. Kayser.** (Astrophys. Journ. 32. pp. 217–225, Oct., 1910.) — Taking as secondary standards the means of three observers' results [see preceding Abstract], an extended list of iron arc lines is given to serve as tertiary standards in the reduction of short portions of spectra. The iron spectrum employed for the determination was photographed in the second order of a Rowland concave grating of 21 ft. radius of curvature. It was found that when the same secondary standards were used, the differences for any line on different plates was only from 0·001 to 0·002 Å.U., whereas with different standards the variation amounted to 0·006 Å.U. This seems to indicate that there are still errors of from 0·004 to 0·005 Å.U. in some of the standards. If one is content with an accuracy to the second decimal, it will be sufficient to subtract 0·19 Å.U. from any measurement on the old Rowland scale to reduce to the new international system. A table of tertiary standards is given from λ4118·553 to λ6494·994. C. P. B.

70. *Periodicity in Satellites of Mercury Lines.* **G. F. Hull.** (Astrophys. Journ. 32. pp. 226–229, Oct., 1910.)—Observations made during the years 1905–6 suggested the probability of regular spacing in the satellites of the

spectrum lines of mercury [Abstracts Nos. 1895 (1906), 688 (1907)]. Such periodicity might result either from an instrumental defect producing ghosts or multiple images, or from various rearrangements of the atomic structure. From a discussion of the measurements of several observers it is concluded that the periodicity shown is real, but more evidence relating to the physical conditions of volatilisation are needed before any definite relation can be found for the series. C. P. B.

71. *Series Spectrum of Mercury.* **S. R. Milner.** (Phil. Mag. 20. pp. 636–642, Oct., 1910.)—Using an arc similar to that described by Pfund [Abstract No. 1259 (1908)], it was found that with the arc *in vacuo* very long exposures could be given (over 50 times the normal). With these long exposures, using a Hilger quartz spectrograph, the lines of the various series of Hg were strikingly developed. The lines of the diffuse series were identified up to $m = 16$, and those of the sharp series to $m = 14$. An exposure of 2 hours gave also members of the principal series which starts in the ultra-red. The series was mapped down to $m = 16$. The frequencies of the lines of the various series are tabulated, and these are used to verify Rydberg's law connecting the series with one another. It is shown that the law is quite accurate for these series. A. W.

72. *X-ray Spectra.* **C. G. Barkla** and **J. Nicol.** (Nature, 84. p. 139, Aug. 4, 1910.)—It was shown by Barkla and Sadler that many elements when subject to a suitable beam of X-rays emit a homogeneous beam of secondary X-rays of penetrating power characteristic of the radiating element. Barkla showed that various groups of these characteristic radiations exist and that each element most probably emits a line spectrum of X-rays, each line moving to the more penetrating end of the spectrum with an increase of the atomic weight of the radiating element. As it was of considerable theoretical interest to confirm the theory by demonstrating the homogeneity of various radiations from some particular element, the writers chose several suitable elements, and by using a penetrating primary beam obtained a mixture of the various secondary radiations characteristic of a particular element. After absorbing the softer constituents, a homogeneous beam of the penetrating secondary X-radiation belonging to group B was left, its homogeneity was proved, and the coefficient of absorption in Al determined. In order to isolate one of the more absorbable constituents, a very soft primary beam was used—too soft to excite the radiation of Group B. After the effect of the scattered radiation was determined by separate experiment and eliminated, this secondary X-radiation was also found to be homogeneous and its absorption was determined. This radiation belonged to Group A. Thus two lines of the spectra of Sb, I, and Ba were determined. J. J. S.

73. *Infra-red Line Spectra.* III. *Accurate Measurements of Wave-lengths beyond* 27,000 *Å.U.* **F. Paschen.** (Ann. d. Physik, 33. 4. pp. 717–738, Oct. 25, 1910.)—A continuation, in the direction of greater wave-length, of previous investigations [see Abstracts Nos. 235 and 1875 (1909)]. Measured wave-lengths are given of all the stronger lines of the alkalies and of Tl between 28,000 and 54,000 Å.U. Some lines not sharp enough to serve as standards were measured to obtain information regarding spectral laws. The results are compared with Moll's observations and with the values calculated from the Ritz equations. Two strong lines at 4 μ and 7·4 μ did not agree with prediction. The line at 4 μ, which was very intense and broad,

was found in all the spectra treated, and also in Cd, Al, Ag, and Hg. Moll observed it with a prism. The 7·4 μ line was found in all the alkaline spectra. Both these lines, and also the Tl line at 7·117 μ, give indication of approximation to hydrogen vibrations. It is suggested that the scale of reciprocal wave-lengths (frequencies) would be preferable, in this class of investigation, to the scale of wave-lengths actually employed. It would appear that in the scale of frequencies the broadening of the lines is nearly uniform throughout, and therefore in the scale of wave-lengths it increases rapidly with wave-length. The breadth of the lines in a spectral series increases with the order, that is, with diminishing wave-length—a property which cannot be represented in a scale that makes the breadth increase with wave-length. Other properties also of spectral series are simpler in the frequency scale. The bulk of the work was done with a Rowland's concave grating, having 142·1 lines to the mm., which had been used by Langley. As it was difficult to slide the bolometer by a large measurable amount along the Rowland circle with the original mounting, a new arrangement was adopted enabling wave-lengths to be determined by angular measurement. The source of light was an arc in air. A supplementary search for lines beyond 4·5 μ was made with a fluorite prism and mirror spectrometer. A modified form of Rubens' thermopile, specially adapted for the investigation, and with diminished heat capacity, is described. A. E.

74. *Spectra of the Anode Rays.* **O. Reichenheim.** (Ann. d. Physik, 33. 4. pp. 747–762, Oct. 25, 1910. Communication from the Physikal-Techn. Reichsanstalt.)—*Results for the Alkalies.*—The anode spectra of Li, Na, K, and Rb, on the whole, resemble their arc spectra as regards relative intensity of lines. The earlier lines of the pairs and some weaker lines of the principal series, and the strongest lines of the 1st subordinate series were observed, but no lines of the 2nd subordinate series. *Results for the Alkali-earths.*—The anode-ray spectra of Ba, Ca, and Sr are much simpler than their arc spectra. All are of similar type, each spectrum consisting of a series of pairs of equal frequency-difference, and an isolated line (viz., Ca 4227, Sr 4608, and Ba 6142). The pairs behave in a magnetic field like series pairs of alkalies, and are pronounced to be heads of doublet series. No other known lines of the earth-alkalies—none of the triplet series—were found, with a faint exception. *Cadmium and Fe* salts were also examined. No lines were found in the visible spectrum of Cd, except some due to hydrogen rays. Possibly there may be lines in the ultra-violet. The iron rays could only be obtained with ferric, not with ferrous, salts; whence it is deduced that they are probably composed of trebly charged, not doubly charged, ions. The beam has a greenish tint, and has intense green and blue lines. The iron spectra were too fleeting to be observed with other than a pocket spectroscope, but gave the impression of being simpler than the arc spectra. In the earth-alkalies changes of relative intensity of lines were found which were *not* due to change of velocity. With Ba rays the relative intensity of the isolated line 6142 and the pairs varies, with position in the ray, to such an extent that the apex of the cone is red and the rest greenish-blue. With Ca and Sr, changes with time are observed when the anode has been long in use. The Ca line 4227 is at first much stronger than the pair 393–396, but after some hours the line is only $\frac{1}{10}$ as intense as the pair. Such relative faintness of the line is found with no other terrestrial source, but something similar occurs in the solar prominences. The author suggests that the solar prominences may be anode rays, the sun taking the place of the anode. The velocity of the prominences is of the

same order as that of the anode rays. *Doppler-effect.*—The alkali lines show the Doppler-effect. It was found with Na in the D lines, and with Li in the lines 671, 610, *i.e.*, in a line each of the principal and 1st subordinate series. Its magnitude points to a unit-charge ion—a result agreeing with that deduced from measures of magnetic deflection. A plate exposed for 4 hours to Sr rays shows the line 4608 with 2 components—one short, sharp, and stationary, the other long and shifted towards the violet. But in the lines 4216, 4078, and 4306, 4162 *the stationary component is missing;* they are single, and shifted towards the violet. The explanation is that the line 4608 is emitted by both ray and anode, and the other lines only by the ray. All the shifted lines are sharp only on the violet side. On a calcium-ray photograph the stationary component is missing in the lines 3969–3934, the only pair recorded. This failure of the stationary component forms a point of distinction between anode and canal rays, though it may be noted that Strasser found a fading of the stationary lines in canal rays in pure hydrogen. Calculation of *e/m* for the Sr pair 4216–4078 from the Doppler-effect indicates that the carriers are doubly charged ions, or at least received their acceleration as such. Values of *e/m* for the Ca pair 393–396 point to the same conclusion. This also agrees with the results of measures of magnetic deflection for earth-alkalies. A final discussion of the hypotheses of Lenard, Fredenhagen and Stark [see Abstracts Nos. 1343 (1907) and 2883 (1904)] leads to the conclusion that Stark's explains the facts most simply. A. E.

75. *Effect of Temperature on Fluorescence and Absorption.* III. *Absorption of Various Specimens at High Temperature.* **R. C. Gibbs.** (Phys. Rev. 31. pp. 463–488, Oct., 1910.)—A continuation of the work done on uranium glass [see Abstracts Nos. 554 and 919 (1910)]. The substances investigated consisted of various coloured glasses of unknown composition, a few cubes the composition of which was partly known, and a cube of fluorite. Only a few showed any fluorescence. The temperatures ranged from room to 400° C. The results are illustrated by curves showing percentage transmission for each wave-length at various temperatures. The cube of fluorite, which showed purple fluorescence, was permanently changed from a muddy specimen to a clear one by heating to 400° C. The essential results are: (1) Heating sometimes increases the absorption, and sometimes decreases it. Though increase may occur more frequently, the existence of decrease has been amply proved. (2) The selective absorption bands are shifted by heating, in some cases towards the longer wave-lengths but in others towards the shorter. The latter phenomenon appears not to have been noticed before. (3) In certain cases a permanent change in the absorption has been found. A. E.

76. *Phosphorescence produced by the α- and β-Rays.* **E. Marsden.** (Roy. Soc., Proc. Ser A. 84. pp. 548–561, May 11, 1910.)—The effect of continued bombardment of α-particles on a screen of zinc sulphide was observed, and it was found that the number and intensity of the scintillations was diminished after some hours' bombardment. The total luminosity was also noticed to decrease with continued bombardment, and it was found that when RaEm was used the luminosity decayed quicker than the emanation. The quantitative observations made are expressed in tables and curves. The effect of temperature was observed in tubes containing emanation and zinc sulphide. The luminosity at 100° was about 6 per cent. less than at 15° C. In general, luminosity appears to decrease with rise of temperature. The illumination

under infra-red rays was 5 per cent. less than that without. Willemite behaves similarly to zinc sulphide, but the rate of decrease of luminosity with time is not so great. Barium platinocyanide shows similar effects, but the greater decay of the luminosity than that of the emanation was very much more marked. When acted on by the emanation in such a way that the α-rays were cut off by the walls of a glass tube so that the β-rays only were effective, zinc sulphide showed an increase of illumination to a max. value in 20 min., followed by a slow decrease when the emanation was removed. With willemite under the action of β-rays there was a small rise of 6 per cent. in illumination to a max. value after about 1¼ min. On withdrawal of the β-rays the illumination fell to a very small value in a fraction of a sec. The behaviour of barium platinocyanide resembled that of willemite. In both cases infra-red had very little effect on the illumination. The effects of excitation by β-rays resemble in many respects those found by Nichols and Merritt for zinc sulphide in the case of excitation by light. J. J. S.

77. *Luminosity produced by α-Rays.* **E. Rutherford.** (Roy. Soc., Proc. Ser. A. 84. pp. 561–572, May 11, 1910.)—Referring to the paper by Marsden [see preceding Abstract] in which it is shown that the actual number of scintillations observed for a constant source of α-rays changes very little with continued bombardment, but the brightness of the scintillations rapidly diminishes, the author discusses the origin of the luminosity produced. The α-particle probably produces ions in a solid as well as in a gas, and the absorption of the α-particles is due mainly to the energy used up in the process. If the solid matter is composed of complex molecules the latter will be dissociated by the α-particles. Pure zinc sulphide does not exhibit the scintillation effect, and the number of molecules concerned seems to be only a small fraction of the total number, as the amount of impurity present is of the order of 1 per cent. These "active centres" will, on the average, be uniformly distributed among the inactive molecules. In the theory of the decay of luminosity given in this paper it is supposed that a scintillation results from the dissociation of a number of these active centres which lie in the path of the α-particle. Each active centre when dissociated by an α-particle emits light and is no longer effective in producing light when struck again by an α-particle. The effect of continued bombardment by α-particles is thus to destroy gradually the active centres. Since, probably, initially many thousands of these centres lie in the path of an α-particle the effect of a continued bombardment will not cause a diminution in the number of scintillations, but a decrease in the intensity of each scintillation, for the intensity of a scintillation on an average will be proportional to the number of active centres remaining. This agrees with the experimental results obtained by Marsden. For willemite and zinc sulphide the active centres have dimensions comparable with a molecule. This excludes the suggestion formerly put forward that the scintillations of zinc sulphide due to α-particles were a consequence of the mechanical cleavage of small crystals. J. J. S.

78. *Properties of easily absorbed Röntgen Radiation.* **R. Whiddington.** (Cambridge Phil. Soc., Proc. 15. pp. 574–575, Oct. 20, 1910.)—This is a preliminary communication. As the result of the experiments it has been found that there is a certain kathode-ray velocity below which no Röntgen radiation can be detected. Using kathode rays produced by a potential of 2500 volts and over, the antikathodes arrange themselves in the following descending order as radiators: Al, Pt, Ag, Pb, Sn, Ni, Cd, Fe, Sb, Cu, Zn; Al at

these low potentials being 5 times as efficient an antikathode as Cu. Antimony has a tendency at greater potentials to take a higher position in the scale. There is strong evidence in favour of the view that Al and Pt give out characteristic secondary radiations. The mass absorption coefficient (λ/ρ) in Al is about 600. There is reason to believe that this secondary radiation can be excited by a primary radiation somewhat less penetrating than itself. The emission of secondary radiation from Al and Pt is accompanied by corpuscular emission. The investigation is being continued at higher potentials. A. E. G.

79. *Number of α-Particles emitted by the Emanations of Actinium and Thorium.* **H. Geiger** and **E. Marsden.** (Phys. Zeitschr. 11. pp. 7–11, Jan. 1, 1910.)—The method employed is to arrange two parallel zinc-sulphide screens at a very minute distance apart. The radio-active material being between these screens, every α-particle emitted will cause a scintillation to take place on one or other of the screens. These scintillations are observed through two microscopes placed so that their fields of view embrace exactly opposite areas of the two screens. From the observations it appears highly probable that the atom of actinium emanation in decaying emits two α-particles at the same time. Should, however, an intermediate decay product exist, its mean life period must be less than $\frac{1}{10}$ sec. With the thorium emanation the scintillations follow one another in quick succession in the same portion of the field of view, indicating that probably four α-particles are emitted when an atom of the emanation breaks up. There appears at least one α-ray product in the thorium emanation group, which has a mean life period of about $\frac{1}{5}$ sec. A. E. G.

80. *New β-radiation from Thorium X.* **O. Hahn** and **L. Meitner.** (Phys. Zeitschr. 11. pp. 493–502, June 1, 1910. From the English.)—The authors have previously explained that from the behaviour of Ra in emitting α- and β-rays they have been led to the hypothesis that it is not a single substance, but consists of two, which they distinguish as Ra and RaX. They consider that Ra itself sends out only β-rays, whilst RaX emits α-rays. In the present paper an account is given of experiments on Th and the Th series. Thorium X appears to emit a β-radiation of feeble penetrating power, and this behaviour is analogous to the emission of the weak β-radiation of Ra. Thus a further step is taken in the completion of the comparison of the dissipation series of Ur and Th. J. J. S.

81. *Structure of the γ-Rays.* **E. Meyer.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 32. pp. 647–662, 1910.)—After referring to the various hypotheses brought forward to explain the nature of the γ-rays, the author describes experiments he has carried out to decide the question whether the γ-radiation is isotropic or anisotropic, *i.e.*, whether it is propagated in all directions equally within the spherical angle 4π, or chiefly in one direction or within an angle small compared with 4π. Whilst the errors of observation in the experiments were large—about 10 per cent.—yet the author considers the conclusion must be drawn that in the γ-radiation from Ra we have to do with a strong anisotropic structure. J. J. S.

82. *Treatment of Pitchblende Residue.* **H. Souczek.** (Akad. Wiss. Wien, Sitz. Ber. 119. 2a. pp. 871–876, March, 1910.)—The paper deals with measurements of the Ra-content of the residues of 30,000 kg. of pitchblende con-

taining 53·4 per cent. U_3O_8, from which Haitinger and Ulrich extracted 8·24 gm. of anhydrous $RaCl_2$ [Abstract No. 150 (1909)]. The authoress has determined the amount of Ra left behind in their residues, and finds it to correspond to 0·26 gm. $RaCl_2$, thus making 8·50 gm. $RaCl_2$ as the Ra-content of the whole amount of mineral. E. M.

83. *Radium-content of the Atmosphere.* **V. F. Hess.** (Akad. Wiss. Wien, Sitz. Ber. 119. 2a. pp. 507–518, April, 1910.)—Discusses the corrections which should be applied to the results obtained by Kohlrausch and Kurz for the induction-content of the atmosphere. Both these investigators used Gerdien's method [see Abstract No. 186 (1906)], and the author here shows, from the constants of the apparatus employed, that the value obtained by Kohlrausch should be multiplied by 2·63, and that of Kurz by 2·26. The corrected results for the RaA-content of the atmosphere then become 16×10^{-6} e.s. unit per $m.^3$ (Kurz at Giessen), 11×10^{-6} e.s. unit per $m.^3$ (Kohlrausch in Gleinstätten). These values agree very well with Gerdien's value ($12·38 \times 10^{-6}$) obtained in Göttingen. [See also Abstract No. 1448 (1910).] A. W.

REFERENCES.

84. *New System of Correction Lenses.* **H. Boegehold.** (Zeitschr. Instrumentenk. 30. pp. 302–307, Oct., 1910. Communication from the Optical Workshops of Carl Zeiss.)—Gives the calculation of a lens system which, when added to an objective corrected chromatically for one pair of wave-lengths, corrects it for another pair. G. E. A.

85. *Auto-collimating Prism and Spectrograph.* **C. Féry.** (Engineering, 90. pp. 519–520, Oct. 7, 1910. Paper read before the British Assoc. at Sheffield.)—An auto-collimating spectrograph in which is employed a quartz prism of small angle with spherical surfaces, of which the one with larger curvature is made reflecting with tin-foil and mercury. E. C. C. B.

86. *Photographic Objectives.* **F. P. Liesegang.** (Deutsch. Phys. Gesell., Verh. 12. 20. pp. 824–828, Oct. 30, 1910. Paper read before the 82. Naturforscher-versamml., Königsberg, Sept. 22, 1910.)—A discussion of the diaphragms, &c., for use with photographic objectives; does not admit of brief abstract. A. W.

87. *Absolute Indices of Refraction in Strained Glass.* **L. N. G. Filon.** (Roy. Soc., Proc. Ser. A. 84. pp. 572–579, May 11, 1910.)—This paper gives an application of the author's method previously described [Abstract No. 1630 (1907)] by which the double-refraction in strained glass can be measured by observing the deviation of a ray of light passing through a slab of glass under flexure. J. J. S.

88. *Optical Constants of Metals from Polarisation Measurements.* **W. v. Uljanin.** (Phys. Zeitschr. 11. pp. 784–789, Sept. 15, 1910.)—After establishing a formula for the relation between the polarisation of the light reflected from the metal and the optical constants of the metal, a description is given of an apparatus consisting essentially of an analyser moving in a vertical circle at the centre of which the reflector is fixed horizontally. The metals Hg, Ni, and Al were examined by means of red, yellow, and blue light, and the ratio of the intensities of the components of the reflected light is shown by means of curves and tables. The refractive indices and extinction coefficients are also given. G. E. A.

89. *Light reflected from Metal Films.* **C. Statescu.** (Ann. d. Physik, 33. 5. pp. 1032–1058, Nov. 10, 1910. Extract of Inaug. Dissertation, Göttingen.)—Gives in ten tables the results of observations on the light reflected from thin metallic films and deals with the following metals: nickel films on copper, on silver and on gold, gold deposited on nickel, copper films on silver, on iron, on gold and on nickel. E. H. B.

90. *Optical Constants of Metals.* **W. Voigt.** (Ann. d. Physik, 33. 4. pp. 833–838, Oct. 25, 1910.)—A supplement to the author's previous paper on the method of A. L. Bernoulli for the determination of the optical constants of metals. [See Abstracts Nos. 1394 (1909) and 1449 (1910).] E. H. B.

91. *Use of the Grating in Interferometry.* **C. Barus.** (Amer. Journ. Sci. 30. pp. 161–171, Sept., 1910. Abstract from Report to the Carnegie Inst., Washington.)—An extension and application of the principles put forward in a previous paper [see Abstract No. 1268 (1910)]. E. C. C. B.

92. *Spectral Series.* **F. A. Saunders.** (Astrophys. Journ. 32. pp. 153–178, Sept., 1910.)—The series lines of Ca, Sr, and Ba have already been dealt with [Abstracts Nos. 569, 917 (1908); 62 (1909); 101 (1910)]. The present paper gives a full account of these series, as far as they are known at present, together with tables of the arc spectra of the elements. A. W.

93. *Infra-red Line Spectra. Spectra of Ag, Cu, Cs, Rb, Sr, and Ba from* 8,000 *to* 30,000 *Å.U.* **H. M. Randall.** (Ann. d. Physik, 33. 4. pp. 739–746, Oct. 25, 1910.)—The investigation in Paschen's earlier papers [see Abstracts Nos. 235 and 1875 (1909)] is extended to further elements, for which tables of wave-lengths are given. Each spectrum was examined and measured throughout the region mentioned, except Rb, for which only predicted lines were measured. Paschen's grating spectrobolometer was employed, with the plane grating and arc lamp used before, and a similar galvanometer and thermopile. A. E.

94. *Infra-red Absorption Spectra.* **W. Weniger.** (Phys. Rev. 31. pp. 388–420, Oct., 1910.)—An apparatus has been built for taking graphic records of infra-red absorption spectra. In the investigation are discussed: The effect of isomerism; Effect of homology; Effect of certain groups; Effect of mode of linking; Effect of number of one kind of group; Effect of polymerism. The results agree with the conclusions of Abney and Festing, and of Coblentz, that the spectra of chemically similar compounds are similar. L. H. W.

95. *Asymmetry in the Zeeman-effect.* **A. Dufour.** (Journ. de Physique, 9. pp. 277–297, April, 1910.)—An expanded account of work previously dealt with [see Abstracts Nos. 1221 (1909), 75 (1910)].

96. *Tables of Ionisation Constants and of Radio-activity.* **T. H. Laby.** (Le Radium, 7. pp. 189–196, July, 1910.)—A collection of tables of data relating to Recombination; Diffusion; Mobility; Condensation; Charge; Number of molecules per unit volume; Ratio e/m; Magnetic deviation.

97. *Short-time Phosphorescence of Certain Compounds.* **C. A. Zeller.** (Phys. Rev. 31. pp. 367–375, Oct., 1910.)—The four groups of compounds examined were: the aniline dyes in their solid form; a group of Mn compounds; of four Cd compounds; and of four phosphorescent sulphides.

HEAT.

98. *Properties of Fused Silica.* **G. W. C. Kaye.** (Phil. Mag. 20. pp. 718–728, Oct., 1910.)—This paper commences with a summary of experimental work done on the expansion of fused silica, transparent and translucent, from 1903 up to the present time. Work at the National Physical Laboratory has established the existence in fused silica of hysteresis for moderate temperature-ranges. It is of interest to note that the quantitative values of this hysteresis are of a lower order than are those for Jena glass and invar. Thus in after-effect due to temperature-change, fused quartz (transparent or translucent) has nothing to fear by comparison with either of these, its most likely rivals. A fused silica standard of length is now coming into use at the National Physical Laboratory. P. E. S.

99. *Heat Conduction by Metal Powder.* **G. Pfleiderer.** (Ann. d. Physik, 33. 4. pp. 707–716, Oct. 25, 1910.)—Describes research on the conducting power of metal in the form of powder, undertaken with the object of determining whether the diminution of heat conductivity (λ) was or was not of the same order as the alteration of the electrical conductivity (χ). The metal used was silver, results for which have been previously obtained by Streintz, Kohlrausch [Abstracts Nos. 186 and 527 (1900)], and Jaeger and Diesselhorst. Using compressed powder the author finds the ratio χ/λ to be $1{\cdot}39 \times 10^5$, which agrees as well as can be expected with the value $1{\cdot}36 \times 10^5$ obtained by Jaeger and Diesselhorst. For solid silver the ratio found was $1{\cdot}41 \times 10^5$, as against $1{\cdot}46 \times 10^5$ by Jaeger and Diesselhorst. For uncompressed powder $\chi/\lambda = 1{\cdot}43 \times 10^5$. Hence, allowing for experimental errors, it appears that the ratio is practically the same for powdered silver as for the solid metal.

A. W.

100. *Behaviour of Water at High Pressures and Low Temperatures.* **G. Tammann.** (Zeitschr. Phys. Chem. 72. 5. pp. 609–631, May 3, 1910.)—Four varieties of ice are indicated: Ice I., or ordinary ice, and Ice IV. (a less stable variety) are lighter than water, and their melting-points are therefore lowered by pressure. Ice III. and Ice II. (less stable) are denser than water, and their melting-points are raised by pressure. Considering first the stable equilibria, the melting-point of Ice I. falls from 0° to —22° at 2200 kg./cm.^{2}; at greater pressures Ice III. crystallises from the liquid, and the freezing-point begins to rise again. If the temperature is below —22°, the effect of great pressure is to change the light Ice I. directly into the dense Ice III. without any intermediate melting, the pressure required to bring about the change decreasing somewhat as the temperature falls. At temperatures below —130° the Ice III. persists in a metastable state on removing the pressure; unlike Ice I., it sinks in liquid air instead of floating, but at —130° it reverts to the ordinary form of Ice I., and crumbles to pieces owing to the large alteration of volume which accompanies the change. Although Ice I. changes to Ice III. under a pressure of about 2200 kg./cm.^{2}, the spontaneous crystallisation of water generally results in the formation of Ice I. in a metastable form at all pressures up to 2500 kg.; above this pressure the denser Ice III. is formed spontaneously, and the water contracts on freezing; a

bomb containing water under a pressure of 2500 kg./cm.^{2} or over could not therefore be burst by freezing, which would, on the contrary, relieve the pressure. The separation of Ice I. in a metastable form permitted the freezing-point curve to be extended from —22° at 2200 kg. to —27° at 2585 kg./cm.^{2}; new values for lower pressures are also given as follows :—

t	—5·53	—7·46	—9·75	—10·42	—12·74	—15·66°
p	675	859	1099	1141	1353	1597 kg./cm.^{2}

It is suggested that the effect of pressure is to increase the proportion of simple molecules in water, and that the denser forms of ice (III. and II.) which are produced under high pressures consist of simple molecules, whilst the lighter forms (I. and IV.) consist of complex molecules. When ice, formed under pressures up to 1500 kg., was allowed to melt, it was noteworthy that the pressure sometimes dropped abruptly at a temperature a little below the melting-point, then rose again to fall rapidly once more when the true melting-point was reached; this was attributed to the accidental production in the original freezing of an Ice IV., which after partial melting solidified to ordinary Ice I., and then melted at the usual temperature for this variety: the change of volume when 1 gm. of Ice IV. passes into Ice I. amounts only to 0·0029 c.cm., so that the two forms resemble one another very closely. The conditions under which Ice II. is formed are only referred to incidentally in the present paper, but it is shown that its spontaneous change into Ice I. on partially or wholly releasing the pressure takes place at precisely the same temperatures as in the case of Ice III., indicating once more the broad distinction between Ice I. and IV. on the one hand, and Ice II. and III. on the other, and the substantial similarity of the members of each group. T. M. L.

101. *Specific Heats at Low Temperatures and the Development o, Thermodynamics.* **W. Nernst.** (Journ. de Physique, 9. pp. 721–749, Sept., 1910. Paper read before the Soc. franç. de Physique, April 1, 1910.)—The author gives an account of the new theorem of thermodynamics put forward by him some years ago, with examples of its application to various chemical systems. At the same time he describes determinations of specific heats at low temperatures carried out by him and various collaborators. Where the mean specific heat only is required, the calorimeter consisted of a hollow block of copper placed in a Dewar vessel, which in turn was placed in a bath of constant temperature. The substance under investigation, contained in a thin silver vessel, was heated to a definite temperature and then dropped into the copper calorimeter, the change in temperature of which was determined by thermo-electric couples. In order to determine the specific heat at a given temperature, a known amount of heat was imparted to the substance by passing a known amount of electricity through a wire surrounding the substance and determining the rise in temperature produced. In this case the Pt heating wire served also as a resistance thermometer. According to Einstein the specific heat of a crystalline substance is given by—

$$c = 3\mathrm{R}e^{-a/\mathrm{T}}(a/\mathrm{T})^2/(e^{-a/\mathrm{T}} - 1)^2,$$

where R is the gas constant. The author and Magnus find that this is only an approximation, and have added a term $b\mathrm{T}^{3/2}$. According to this equation the specific heat increases with the temperature and reaches a maximum, which is approximately the Dulong-Petit atomic heat. This is confirmed by the author's experiment. A. F.

102. *Variation of Radiation of a Bunsen "Plate" with Angle of Emergence.* **O. Lummer and F. Reiche.** (Ann. d. Physik, 33. 5. pp. 857–870, Nov. 10, 1910.)—The radiation received on an element of surface from a hot layer of gas is expressed in terms of the angle of emergence, a, and the thickness of the layer, D, the transmissive power of a layer of thickness $D/\cos a$ being $\epsilon^{-KD/\cos a}$. For a thickness D, for which the product KD is very small, the energy radiated should be independent of the angle of radiation. This was tested by means of a flat Bunsen "plate" or flame, 14 cm. long, 8½ thick, and 8 cm. high, the radiation from which was measured at angles of emergence varying from 0° to 60° by means of a fluorspar prism and a bolometer. The use of the prism enabled a separation of the CO_2-radiation from that of the water-vapour. The theoretical law of radiation deduced is verified by the measurements. Also, the absorptive power of the layer of CO_2 found was 86 per cent., that of the water-vapour 18 per cent. By a direct measurement the absorptive power of the plate of CO_2 was determined as 80 per cent. The ratio 80/86 appears to correspond with Buchwald's result, viz., that a layer of CO_2, which was expected to absorb 100 per cent. of the radiation from a Nernst lamp, absorbed only 79 per cent. G. E. A.

103. *Convection of Heat from a Body cooled by a Stream of Fluid.* **A. Russell.** (Phil. Mag. 20. pp. 591–610, Oct., 1910. Paper read before the Physical Soc., July 8, 1910.)—The author gives proofs of several of Boussinesq's formulæ for the convection of heat at the surface of a body immersed in a cooling liquid which flows past with appreciable but not excessive velocity. The limitations of the formulæ are clearly stated and several important applications are pointed out. The cases worked out in greatest detail are those in which the solid is a circular or elliptic cylinder or a flat strip. The author also discusses the problem of the heating, due to streamline convection, of a liquid flowing through a cylindrical tube, and gives a table by means of which approximate solutions can be found. The paper concludes with a discussion of three important practical problems, viz., the electric current necessary to fuse a wire, the steady temperature attained by a wire carrying an electric current, and the effect on the convection of heat from a cylinder of putting a covering round it. A. D. R.

104. *Proposed Method of Calibration of Optical Pyrometers.* **G. A. Shook.** (Phys. Rev. 31. pp. 342–357, Oct., 1910.)—Wien's law may be written: $\log_{10} J = K_1 - K_2/T$, where K_1 is a constant, $K_2 = C_2 \log \epsilon/\lambda$, and J is the energy corresponding to wave-length λ; C_2 is 14,500 for a black body. The above equation may be applied to any pyrometer using monochromatic light, in which the luminous intensity can be varied in a continuous and determinate manner, as in the Wanner and le Chatelier instruments. The equation is modified to express the temperature (Cent.) in terms of the luminous intensity, and the object of the paper is to show that only one known black-body temperature is necessary to standardise the pyrometer comparison lamp, and that this black-body temperature can be obtained by means of a secondary standard. Calibrations of the Wanner and le Chatelier pyrometers are detailed to illustrate the method. G. E. A.

SOUND.

105. *Sensibility to Pitch.* **H. Muraoka.** (Coll. Sci. and Engin., Mem. Kyōtō, 2. 8. pp. 268–276, 1910.)—Describes a test of the psychophysical law which Fechner calls Weber's law, as applied to the pitches of notes and our sensibility to small differences in them. The law may be written—

$$dh = C dn/n = \text{constant},$$

where C is a constant, n and dn are frequency and its increment, dh being the corresponding change of perception of the pitch. In three series of experiments, using notes from 128 to 1280 per sec. produced by a string, Weber's law was substantially confirmed. In experiments on air, however, it was found that dn, rather than dn/n, remained about constant. E. H. B.

106. *Radiation of Sound from Explosions.* **G. v. der Borne.** (Phys. Zeitschr. 11. pp. 483–488, June 1, 1910.)—It has been observed that in the immediate vicinity of sources of sound of great intensity there is a region of *normal audible-distance*, then a zone about 100 km. wide where the sound is inaudible, followed finally by a very greatly extended region of *abnormal audible-distance.* For these phenomena the following explanation is here offered. In the lower or foundation layers of the atmosphere, in which the temperature falls as we ascend and the molecular weight of the air is practically constant, the sound rays are concave upwards. In the higher layers, they are concave downwards and accordingly return, because in the higher regions of the atmosphere there is a larger proportion of the lighter gases, hence the molecular weight of the air is less and the speed of sound greater. The wind has only a slight influence in these phenomena. The calculation of the effect on the above principle is in good agreement with observation. E. H. B.

107. *Sound Speed in Potassium Vapour.* **W. Wenz.** (Ann. d. Physik, 33. 5. pp. 951–970, Nov. 10, 1910. Extract of Dissertation, Marburg.)—By means of a special resonance tube that could be filled with air or potassium vapour, the speed of sound in the latter at 850° C. was found to be 652 m./sec. Taking the value of γ, the ratio of specific heats in air at that temperature to be 1·39 after Kalähne, the value of γ for potassium vapour is calculated to be 1·77, showing it to be monatomic. [See Abstract No. 1699 (1908).] E. H. B.

108. *Correction for Open End of Cylindrical Resonator.* **W. M. Boehm.** (Phys. Rev. 31. pp. 332–341, Oct., 1910.)—Cylindrical tubes of various thickness of flange were used, and by extrapolation the results for "zero" flange and infinite flange are obtained. The average values for the corrections in these cases are respectively 0·656 R and 0·871 R, where R is the radius of the tube. The first is 15 per cent. above Blaikley's value, while the second is 6·5 above the probable value given by Rayleigh. E. H. B.

109. *Transmission, Absorption, and Reflection of Sound.* **F. Weisbach.** (Ann. d. Physik, 33. 4. pp. 763–798, Oct. 25, 1910. Abstract of Dissertation, Leipzig.)—From the series of experiments undertaken the author draws the

following conclusions: (1) A tuning-fork with resonance box in connection with a tuning-fork interrupter gives a very constant, powerful, and measurably variable source of sound. (2) A telephone (with and without a resonator), combined with a fibre galvanometer, forms a useful, handy instrument to measure relative sound-intensities. (3) The acoustic transparency and reflective power of stretched thin sheets is not immediately measurable, since the transverse vibrations of the plate as a whole often exceeded its sympathetic vibrations. E. H. B.

110. *Pianoforte Sounding-board.* **G. H. Berry.** (Phil. Mag. 20. pp. 652–657, Oct., 1910.)—In a previous paper [Abstract No. 1294 (1910)] it was shown that a section of the sounding-board of a pianoforte had a natural period of vibration of its own, independent of the pitch of the strings upon it, and this natural vibration was apparent in all the photographs there reproduced, the frequencies of string and board being respectively of the order 261 and 50. If the pitch of the sounding-board was the same as that of the string, it seemed reasonable to expect the sound to be considerably reinforced and the sounding-board to act as the air column acts, in the usual resonator fixed to the stem of a suitable tuning-fork. This, however, did not prove to be the case, or, at any rate, a very important modification was found necessary; the conclusions deduced from the experiments being as follows: (1) The vibrations of the sounding-board, when the bridge is near the middle, divide in half with a node at or near the middle. (2) For the middle octaves of the pianoforte, when these two halves have a natural pitch near the pitch of the strings exciting them, a resonance takes place and a good musical tone results. (3) For the two lower octaves the statement in (2) does not apply. (4) Strong second and third partials are detrimental to good musical tone. The paper is illustrated with a series of twenty-five photographic records of the vibrations under various conditions. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

111. *Radiation from Electron Orbits.* **J. H. Jeans.** (Phil. Mag. 20. pp. 642–651, Oct., 1910.)—In the present paper an attempt is made to examine the nature of the radiation which would be emitted by electrons describing orbits about various centres of force, and in fields of force of various kinds, with a view to collecting evidence as to whether black-body radiation can be interpreted as radiation emitted in this way. In previous papers [see Abstracts Nos. 1268 and 1578 (1909)] a proof has been given that if radiation can be explained in this way, the orbits must be described about centres of force varying as the inverse cube of the distance. The present investigation confirms this result in an independent manner, and tests how far such radiation would be in agreement with that observed experimentally.
E. H. B.

112. *Initial Velocity of Electrons as a Function of Wave-length in the Photo-electric Effect.* **J. Kunz.** (Phys. Rev. 31. pp. 536–544, Nov., 1910.)—Working with the apparatus and by the method already described [see Abstract No. 2103 (1909)], and using from a prism beams of various colours incident on the surface of the liquid Na-K alloy, the author found that the max. positive potential acquired by the alloy was proportional to the square of the frequency of the light. This potential was taken as a gauge of the initial velocity of the electrons. E. H. B.

113. *Note on Kirchhoff's Law.* **G. C. Evans.** (Amer. Acad., Proc. 46. No. 4. pp. 97–106, Sept., 1910. Contribution from the Jefferson Phys. Lab., Harvard Univ.)—Kirchhoff's law, in its simple statement, says that the energy radiated at a given temperature divided by the absorption coefficient for that temperature is the same for all bodies of the same shape and size. This relation is easily shown to hold for total radiation, and depends merely on the 1st and 2nd Laws of Thermodynamics. But for separate wave-lengths a reduction of the law to a firm thermodynamic basis, though often attempted, seems not to have been completely obtained. Unwarrantable assumptions, sometimes tacit, seem unavoidably to have been introduced. The author then shows the nature of the assumptions that must be introduced, and attempts to set up a system of assumptions from which the law will rigidly follow. The paper itself is highly mathematical and unsuited to abstraction.
E. C. R.

114. *Adsorption of Ions by falling Water-drops.* **R. Seeliger.** (Ann. d. Physik, 33. 2. pp. 431–435, Aug. 30, 1910.)—The author considers that the charges observed by A. Schmauss cannot be explained by the assumption of a unipolar picking-up of ions from the supply of ions in the space through which the fall takes place: (1) Because they are considerably greater than the charges of all the existing ions in the space considered which can be taken into account; (2) Because they are also observed when there is present in the region of fall only the very small ionic density of the free air space; (3) Because they are independent of the material and the nature of the

surface of the tip of the drop. A thoroughly satisfactory explanation is afforded if these charges are considered as being due to a modification of the water-dropper effect. J. J. S.

DISCHARGE AND OSCILLATIONS.

115. *Nature of Ionisation Produced by α-Rays.* **F. E. Wheelock.** (Amer. Journ. Sci. 30. pp. 233–255, Oct., 1910. Contribution from the Sloane Phys. Lab. of Yale Univ.)—It is well known that when a gas is ionised by α-rays saturation is obtained only when a larger potential gradient is applied between the plates of the chamber than is necessary in the case of ionisation by β- or γ-rays. Bragg and Kleeman [Abstract No. 929 (1906)] originally explained this lack of saturation on the hypothesis of "Initial Recombination," *i.e.*, that the two ions made by corpuscular dissociation of the molecule are situated initially in the immediate vicinity of each other and are thus able to recombine, and escape being carried by the electric field to the electrodes. Moulin [Abstract No. 1435 (1909)] later interpreted the lack of saturation as due to the ions being produced in columns along the trajectories of the α-particles and not initially uniformly distributed in the volume of the gas. The present experiments support Moulin's conclusions and verify Moulin's experiments that the "electric field required for saturation is much less intense" perpendicular to than parallel to the trajectory. The ionisation curve with a parallel field, however, was found to be not altogether in agreement with that obtained on the simple assumption of columnar ionisation; although the ionisation is proportional to the intensity of the source even when far from saturation. The author concludes that the columnar ionisation hypothesis may altogether explain the facts if the distribution of the ions within the columns were known, but, on the other hand, it appears probable that certain outstanding discrepancies may be due to initial recombination. E. M.

116. *Mobilities of Ions produced in Air by Ultra-violet Light.* **A. L. Hughes.** (Cambridge Phil. Soc., Proc. 15. pp. 483–491, Oct. 20, 1910.)—When ultra-violet light passes through a gas it is difficult to obtain evidence of any increased conductivity. Henry and Whiddington [see Abstract No. 80 (1910)] both found that iodine vapour, which absorbs ultra-violet light considerably, shows no such increase. Lenard [Abstract No. 97 (1901)] carried out experiments which appeared to show that air is made conducting under the action of a very absorbable kind of ultra-violet light. He determined the mobilities of the ions so produced, and found for the negative a mobility of 3·13 cm./sec., and for the positive a mobility of 0·0015 cm./sec. The latter is of an order quite different from the mobilities of ions produced by Röntgen rays and the radiations from radio-active substances. This led to the suggestion that the positive carriers in Lenard's experiments are not positive ions but dust particles which have lost negative electricity in accordance with the ordinary photoelectric effects at the surface of solids or liquids, which view was confirmed by the experiments of Bloch. J. J. Thomson, Palmer, and Stark have all been able to obtain increased conductivity due to ultra-violet light, under special conditions. In the present experiments no definite indication of ionisation of the air due to ultra-violet light which has passed through thin quartz plates is obtained, the sources of light used being a mercury arc, the glow in a lime kathode discharge, and the discharge in hydrogen. Fluorite is found to transmit light of shorter wave-length than that transmitted by quartz, so plates of this material are

used in place of quartz plates. The air is drawn in through a wide plug of cotton-wool, and passes up a narrow tube until it reaches the fluorite window. The air then passes into the ionisation chamber through a short glass tube suitably bent to prevent reflection of ultra-violet light on the electrodes. The stream of air flowing through the ionisation chamber is now found to be highly conducting and contains both positive and negative ions, the leak owing to the latter being many times greater than that due to the former. Wilson's expansion apparatus is used to make sure that the positive carriers are not positively-charged dust particles. The method of measuring the mobilities of the ions is a modification of that used by Rutherford and Zeleny in which the ionised air is drawn through a cylinder past two electrodes. For comparative measurements the air ionised by Röntgen rays is used. There appears to be little difference between the mobilities of the ions produced by Röntgen rays and those produced by ultra-violet light, and it is concluded that they may be considered as identical. It is suggested that the ionisation of air by ultra-violet light sets in at some wave-length between λ1230 and λ1450, and increases very rapidly with decreasing wave-length.

A. E. G.

117. *Positive Electrification due to Heating Aluminium Phosphate.* **A. E. Garrett.** (Phil. Mag. 20. pp. 578–591, Oct., 1910. Paper read before the Physical Soc., June 10, 1910.)—J. J. Thomson found that aluminium phosphate when heated gives off a large excess of positive ions [Abstract No. 864 (1907)], and the present paper deals with experiments on the source and nature of this ionisation. The decay with time of the current due to the positive ions was investigated and found to be expressible in the form $A(e^{-\lambda_1 t} - e^{-\lambda_2 t}) + B(1 - e^{-\lambda_3 t})$ suggesting different stages in the process similar to radioactive disintegrations. During the first part of the curve the nature of the surrounding gas and the water contained by the salt were found to have an influence, but when a steady stage had been reached the gas had no apparent influence, but water still temporarily increased the activity. With the pressure constant the relation between the ionisation current and the absolute temperature was found to be expressed by the Richardson formula $I = A\theta^{\frac{1}{2}}e^{-Q/2\theta}$; while when the temperature was kept constant it was found that for each temperature there was a definite pressure at which the current was a maximum, this pressure diminishing with increasing temperature. The value of *e/m* was determined for the positive ions by the cycloid method, and for the lightest ions present found to be of the same order as that for the hydrogen atom. [Compare Horton Roy. Soc. Proc. Nov. 10, 1910.] Several experiments, however, suggested that neutral doublets as well as free ions were ejected from the salt.

E. M.

118. *Specific Charge of the Ions emitted by Hot Bodies.* **O. W. Richardson and E. R. Hulbirt.** (Phil. Mag. 20. pp. 545–559, Oct., 1910.)—Further experiments by the method previously employed by the author [see Abstract No. 117 (1909)] confirm the conclusion then arrived at that the constancy and values of the specific charges and masses of the positive thermions obtained from Pt and carbon, and their practical identity with those obtained by J. J. Thomson from iron, indicated their origin from sodium present as an impurity in each of the metals employed. The materials experimented on included Pt, Au, Ag, Cu, Ni, Fe, Os, Ta, W, brass, nichrome, and steel. Unsuccessful experiments were made upon Al, Mg, and Zn, it being found impossible to obtain sufficient ionisation for the necessary measurements before the strips

of these metals melted. The fact that the values obtained for the ratio of the atomic masses to that of hydrogen tend to run a little higher than the atomic weight of sodium may mean that in most cases there is a small amount of potassium or its compounds present. G. W. DE T.

119. *Positive Rays.* **W. Wien.** (Ann. d. Physik, 33. 5. pp. 871–927, Nov. 10, 1910.)—A detailed exposition of the experimental arrangements for obtaining energy curves of canal rays in various gases. The earlier observations [Abstract No. 961 (1910)] are confirmed, and the results of the present experiments are set forth in a large number of curves. The magnetic deflection of canal rays in hydrogen, oxygen, nitrogen, and iodine vapour, and the electric deflection in hydrogen and oxygen are considered. The paper concludes with a comparison of the magnetic deflection at different potentials and in various gases, and the calculation of the accelerating potential from the magnetic and electric deflections. A note is appended stating that the experiments of Deschend and Hammer—in which still lower pressures in the observation space are used, and the absence of mercury vapour is assured, and yet a preponderance of negative ions in oxygen is obtained—are not in any way contradictory to the present results and conclusions. A. E. G.

120. *New Radiant Emission from the Spark.* **R. W. Wood.** (Phil. Mag. 20. pp. 707–712, Oct., 1910. Phys. Zeitschr. 11. pp. 823–826, Oct. 1, 1910.)—This radiation was discovered over 2 years ago in the course of some experiments made with a view of ascertaining whether the Schumann waves from a spark give rise to any fluorescence of the air by which they are absorbed. It is now known that there is a feeble ultraviolet luminosity of air or nitrogen gas surrounding a small mass of Ra. To test for a fluorescence due to the absorption of very short light-waves, the condenser spark between Al electrodes is passed behind, and very close to, a vertical strip of metal which completely conceals the spark, but which enables observations, either visual or photographic, of the air in its immediate vicinity. If the air in the room is free from dust and smoke, absolutely nothing can be seen with the eye; a photograph, however, made with a small camera provided with a quartz lens, shows that the air around the spark is a source of powerful actinic radiation, which is completely stopped by the intervention of a glass plate between the camera and the spark. These phenomena are not produced by the scattering of the shortest waves by the air molecules or microscopical dust particles, nor by ultraviolet fluorescence of the air caused by the absorption of the Schumann waves. The spectrum of the emission consists of two broad bands, one very strong, the other much weaker. These are found to be identical with the so-called "water bands" of the oxyhydrogen flame. In addition to these bands, in one instance lines are obtained at wave-lengths 3576, 3537, and 3369, which are identical with lines attributed to nitrogen in the spectrograms published by Eder and Valenta of the spark between wet carbon electrodes. The presence or absence of water-vapour does not appear to modify the intensity of the spectrum observed. When oxygen is used in the auxiliary tube which is attached when the emission is studied in dry air or different gases, there is almost no trace of the emission, but when nitrogen is used the emission is much brighter, and extends to a greater distance from the aperture than in air. The magnetic field appears to have no action upon the emission. The material constituting the emission is evidently shot from the aperture at a very high velocity, for it is impossible to blow it aside with a strong jet of air. It seems quite likely that the "Entladungsstrahlen" may

be identical with this emission, for they are absorbed by oxygen. One great difficulty in the investigation is the apparent impossibility of separating the emission from the ultraviolet and visible light which goes out with it.

A. E. G.

121. *Rays of Positive Electricity.* **J. J. Thomson.** (Phil. Mag. 20. pp. 752–767, Oct., 1910. Paper read before the British Assoc. at Sheffield.) —The investigation of positive rays or Canalstrahlen is made much easier by using very large vessels for the discharge tube in which the rays are produced. By this means it is possible to work at lower pressures, and phases of the phenomena of positive rays come to light which are absent or inconspicuous at higher pressures. In this research it has been found that flasks having a volume of 2 litres, such as are used for boiling-point determinations, are large enough for most purposes. A uniform and sensitive phosphorescent screen, made by grinding willemite into exceedingly fine powder, then slowly shaking the powder up in alcohol and allowing it to settle slowly on a flat glass plate, is used to bring out the details well. The appearances of the phosphorescence due to the impact of the positive rays upon the screen when magnetic and electric fields are so arranged as to act simultaneously on the particles, and likewise when these fields are made to overlap, are described in detail. From the results obtained it is considered that positive rays may be divided into the following three classes: (1) The undeflected rays, *i.e.*, rays which are not affected by electric or magnetic forces. The velocity and value of e/m for these cannot be determined directly. (2) Secondary rays produced by (1). As the rays of the first type pass through a gas and collide against the molecules they produce secondary rays; whether they do this by splitting up themselves or by dissociating the molecules against which they strike is uncertain. The rays of this class have a constant velocity 2×10^8 cm./sec. roughly; whatever may be the p.d. between the electrodes they have a constant max. value of $e/m = 10^4$. At the higher pressures when the discharge tube is small these rays predominate and swamp the others; they get fainter and fainter as the pressure is reduced below a certain amount. It is proposed to name these *secondary positive rays.* (3) Rays characteristic of the gases in the tube. These are seen at low pressures, they produce bright spots on the screen; with each spot a thin parabolic band of luminosity is connected, the separate bands forming a kind of spectrum characteristic of the gases in the tube. The velocity of these rays depends on the p.d. between the electrodes, and the value of e/m is inversely proportional to the atomic weight of the gas from which they are derived. Their kinetic energy is that due to the p.d. between the negative glow and the kathode; in a mixture of gases the electrostatic deflection of the rays from each gas is the same. The retrograde rays which start from the kathode and travel away from it in the same direction as the kathode rays belong to classes (1) and (2). Class (3) has not been observed in retrograde rays. In addition to the positively charged rays there are negatively charged ones of type (2), and in some cases of type (3) also. The different gases show great variations in the brightness of the negative tails connected with the rays peculiar to the atoms of the element; some elements show the negative tail readily, while it is not observed at all in others. The absence of the negative part of the phosphorescence indicates a reluctance on the part of the atoms of some gases to acquire a negative charge; this is also brought out by Franck's discovery that in some gases from which oxygen had been completely excluded the velocity of the negative ion was very many times greater than when oxygen

was admitted, while the positive ion was not affected. This indicates that the negative corpuscle does not readily attach itself to the molecules of the gases. If we suppose that the undeflected rays are formed by the recombinations of positive and negative particles and that these by collision with the molecules of the gas through which they pass form rays of type (2) either by splitting up themselves or by dissociating the molecules against which they strike, we can explain why the velocity of these rays should be independent of the p.d. between the electrodes of the tube. For in the first place the positive and negative charges will not unite unless their relative velocity falls below a certain value which does not depend upon the strength of the electric field, and in the next place, if the velocity were less than a limiting value they would not dissociate themselves, nor could they dissociate other molecules by collision when moving through a gas. The first condition gives a superior limit to the velocity, the second an inferior one; and both are independent of the strength of the electric field. A mathematical investigation with details of the measurements of the values e/m and v is given. On the assumption that the charges are equal it is found that the carriers with one exception are in the atomic condition. When primary Canalstrahlen strike against a plate of metal, secondary rays are produced. These are emitted in all directions and are for the most part uncharged, but a small fraction carry a positive charge. [See also Abstract No. 128 (1910).]

A. E. G.

122. *Passage of Electricity across very Minute Air-gaps.* **G. Hoffmann.** (Deutsch. Phys. Gesell., Verh. 12. 21. pp. 880–889, Nov. 15, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 20, 1910. Phys. Zeitschr. 11. pp. 961–967, Nov. 1, 1910.)—A short historical *résumé* of the work on this subject is first given. In the present experiments an iron ring, slit on one side, has wire so wound on it that when a current flows through the wire the ring slightly bends, owing to the action of the magnetic field upon it. The dimensions are so arranged that without any apparent heating effect due to the current, a difference of 1/50 mm. in the distance can be obtained. Arrangements are described for mounting on this apparatus the metals (steel and Pt) with which it is desired to experiment. At the commencement the surfaces of contact are brought to a distance apart of 1/200 mm. The measurement of the motion under the influence of the magnetic force is obtained by observation of the interference rings, which are produced in the front end of the apparatus. The measurements given show that the potential required to produce a current increases proportionally with the distance, and is quite different for the two metals examined. The absolute values of the measurements of the field strengths are of a provisional nature; they are the greatest which have been observed up to the present (millions of volts per cm.). A. E. G.

123. *Potential of Discharge in the Magnetic Field.* **A. Righi.** (N. Cimento, 20. pp. 278–301, Oct., 1910. Le Radium, 7. pp. 285–288, Oct., 1910.)—Three tubes are employed, which differ only in the distance between the Al disc-shaped electrodes. In one this distance is 0·3 mm., in another 1·2 mm., and in the third 8 mm. The pressure in all cases is 0·64 mm. Curves are given which show the connection between the potential of discharge and the magnetic field applied. With longitudinal fields it is seen that with a gradually increasing field up to about 8000 c.g.s. a diminution of the discharge potential first takes place; this continues till a minimum is reached, after which with increasing fields the discharge potential also increases. These effects are the less pronounced the greater the distance between the electrodes. With weak transverse fields the effects are similar to those obtained with longitudinal fields, but with very small distances between the electrodes, as the intensity of the field is increased the discharge potential gradually rises to a maximum, after which for more intense fields it again decreases. In one case the curve is cut three times by the line representing a discharge potential of 460 volts. An explanation of these phenomena is put forward, three causes being assumed to contribute to the result: (1) The modifications which the magnetic field produces in the paths of the electrons emitted by the kathode, and analogous modifications which the paths of the ions undergo. (2) The presence of doublets, the stability of which is modified by the action of the field, *e.g.*, they will gain in stability and are the better able to resist shock when the electron revolves round the ion in the sense of the circular current which creates the field. (3) It seems evident that the magnetic field is able to modify the orbits of the electrons contained in the atoms in the same way in which it modifies those of the electrons in the case of doublets, so that, according to the direction of the field, the separation of the electrons from the atoms by collisions may be made more or less difficult. Should this explanation prove correct, then it must be admitted, in the case in which the discharge is not preceded by a movement of ions on which the field can act, that the only action of the magnetic force is to cause the ionisation of the gas. A. E. G.

124. *Action of Magnetic Field upon the Electric Discharge.* **E. Bloch.** (Comptes Rendus, 151. pp. 808–810, Nov. 7, 1910.)—The experiments of Gouy [see Abstract No. 1125 (1910)] are repeated with a very small tube, and the following further fact is also established: The re-lighting of the discharge by the field parallel to the kathodes no longer takes place if the magnetic field is too strong, so that there is a magnetic field which produces the max. effect. The magnitude of this field increases with the degree of the vacuum, and with the potential under which the discharge is produced. An explanation is given from which it seems that the phenomena pointed out by Gouy are quite in accord with the modern theory of the disruptive discharge.

A. E. G.

125. *Spark-gap in Hydrogen and the Hydrogen Spectrum.* **B. Glatzel.** (Phys. Zeitschr. 11. pp. 894–896, Oct. 15, 1910. Deutsch. Phys. Gesell., Verh. 12. 20. pp. 842–846, Oct. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 22, 1910.)—If a hydrogen spectrum is obtained from an electric spark in hydrogen, the lines are broadened when a capacity is placed in parallel with the spark-gap. The lines remain sharp, however, if the discharge is made aperiodic in the way described in an earlier paper by the author [see Abstract No. 908B (1910)]. The broadening is therefore due to the oscillatory discharge, a slightly irregular radiation being emitted by the hydrogen due to the alternating bombardment to which it is subjected by the metal ions from the electrodes of the gap. This is supported by the fact that where the metal ions are thickest the spectrum lines are broadest. If the spectrometer slit be placed perpendicular to the spark-path, the lines are broadened at the centre, but if parallel the lines are broadened at their ends. The electrodes are of nickel. An attempt is made to observe the Doppler-effect in the lines of the Ni spectrum obtained from the aperiodic discharge, since in this case the metal ions are shot off always from *one* of the

electrodes. The results do not warrant conclusions. Photographs of the hydrogen spectra obtained under all the conditions mentioned above are reproduced. T. P. B.

126. *Characteristics of Arc- and Glow-discharge between Copper Electrodes.* **A. Hagenbach** and **H. Veillon.** (Phys. Zeitschr. 11. pp. 833–847, Oct. 1, 1910.)—The characteristics of the discharge between copper electrodes in air, nitrogen, and CO_2 at pressures ranging from 760 to 20 mm., are obtained. It is found that, in air, there are six characteristic curves. Three anode-falls are possible, one for the arc, another for the glow-discharge, and a third for a discharge which is distinct from either. These three anode-falls give rise to the three chief characteristics. But to each of these three belongs a second, which is due to oxidation at the kathode, and is, therefore, not obtained in nitrogen. The latter three lie lower than the former, as the kathode-fall is less for CuO than for Cu. They are obtained when the arc hisses. Two or more of these six forms may be obtained under the same conditions. All six are here observed at a pressure of 100 mm., a voltage of 440 volts, and a current of 5 amps. In nitrogen the three chief forms are obtained at 500 mm. pressure. For no apparent reason the arc springs from one state to the other. The characteristics of the arc- and glow-discharge are explained by the ordinary theory of electric discharge. The nature of the third discharge is not quite clear. T. P. B.

127. *Electrical Oscillations of Very High Frequency but Low Damping.* **G. Mie.** (Deutsch. Phys. Gesell., Verh. 12. 20. pp. 860–866, Oct. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 19, 1910. Phys. Zeitschr. 11. pp. 1035–1038; Discussion, pp. 1038–1039, Nov. 15, 1910.)—An oscillator is described the oscillation of which has a wave-length of about 20 cm. and a logarithmic decrement varying from 0·04 to 0·1. It consists of two metal plates on opposite sides of a sheet of ebonite 0·2 mm. thick. The plates are quadrants of a circle of 1 cm. radius. The points of the quadrants are bent round one edge to form a spark-gap of considerable electrode surface. To the sides of the spark-gap are attached two parallel wires bent apart at the ends. The length of the wires is made about ¼ wave-length of the oscillator oscillation. Energetic oscillations result. This is due to the quenching of the spark before the oscillation energy is dissipated. The system thereafter oscillates with little damping. The spark length must be very small, 0·1 mm., and the spark must take place in oil or coal-gas. The frequency of oscillation may be altered nearly an octave by altering the length of the attached wires. A very sharply pointed resonance curve is given. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

128. *Electric Conductivity and Temperature Coefficients of Alloys.* **W. Guertler.** (Phys. Zeitschr. 11. pp. 476–479, May 15, 1910.)—This is the concluding portion of a long account of researches on the behaviour of alloys, and especially of the connection between the conductivity and temperature-coefficients and the constitution of the various alloys. The results given by le Chatelier are in general confirmed but are modified in certain details. The conductivity of those alloys which consist of heterogeneous mixtures of two crystalline substances, when shown in a curve in relation to the concentration give, to a first approximation, a straight line; yet this approximation becomes less with increasing difference of the values of the conductivity of the two components. J. J. S.

129. *Atomic Magnitude and Temperature Coefficients of Resistance.* **F. Streintz.** (Ann. d. Physik, 33. 2. pp. 436–440, Aug. 30, 1910.)—The author deduces a simple relation between the atomic volumes of the metals in numerous cases and the temperature coefficients of the resistance. The data are derived from the measurements carried out by Jaeger and Diesselhorst. The atomic volume is obtained by dividing the atomic weight by the density. The cube root of this volume multiplied by the "proportional factor" (180·2 in the case of Pd, Pt, Al, Ag, Au, Cd, Sn) gives a number closely agreeing with the temperature-coefficient multiplied by 10^5. J. J. S.

130. *Resistance of Metallic Mixtures and Alloys.* **K. P. Brooks.** (Phys. Zeitschr. 11. pp. 471–473, May 15, 1910.)—Rayleigh suggested as an explanation of the high resistance of alloys that there may be an opposing e.m.f. produced at the junctions of neighbouring particles of the two components of the alloy. This oppositely directed e.m.f.—the Peltier-effect—would have the same result as an ohmic resistance. The author's experiments were arranged to test whether this hypothesis gave a true explanation of the phenomena. A pile of plates of different metals, first gold and silver, was formed, and these were pressed together in a tube and tested for resistance under various conditions of current strength. The result was that none of the characteristic peculiarities of an alloy were shown. Similarly when powders composed of different metals were tested their behaviour was not the same as that of an alloy of these metals. The structure of alloys which causes their high resistance is thus shown to be different from that of a mere arrangement of particles close together. J. J. S.

131. *The Silver-Nickel Thermo-element.* **G. v. Hevesy** and **E. Wolff.** (Phys. Zeitschr. 11. pp. 473–476, May 15, 1910.)—A combination of two wires of silver and nickel was formed, and the thermo-e.m.f. between −80° and +920° examined. The junction was found to be very suitable for temperature measurements between these limits. The thermo-e.m.f. rose continuously from −80 to 920°, and showed neither a neutral point nor point of inversion. The value of the e.m.f. increased from 1·676 millivolts at the lower temperature to 24·878 millivolts at the higher. When the temperature-coefficient dE/dT is taken as ordinate with the temperature as abscissa the coefficient is found to increase up to about 180°, then decreases to a minimum at 370°, after which it rises again to 780°, and then remains constant. A similar minimum, at about 380°, was found by Harrison in the case of the Cu-Ni element. The Ag-Ni element is found to be easily reproducible with an accuracy within about ± 0·5° C. The temperature of the minimum, 370°, coincides with that of the change-point of Ni. J. J. S.

132. *Polymorphism and Electrical Resistance of Zinc.* **C. Benedicks.** (Metallurgie, 7. pp. 531–537, Sept. 8, 1910.)—After a brief review of the literature on the allotropy of Zn, the author describes a series of tests on the electrical resistance at various temperatures on one sample of pure Zn and two commercial zincs. U-shaped test-pieces were prepared and heated to the desired temperature, measured by a thermo-junction, in a Heraeus electric furnace. A current was then passed through the test-piece and the fall of potential between the two ends measured by means of a galvanometer. The results are plotted in the form of resistance-temperature curves which for pure Zn show two discontinuities, one at 340° C. agreeing fairly closely with the one previously discovered by le Chatelier, and a second one at

170° C., agreeing with the change in mechanical properties of Zn occurring about this temperature. It appears therefore that Zn exists in three allotropic forms—α-zinc up to 170° C., β-zinc between 170 and 330° C., and γ-zinc between 300 and 419·4° C. The curves for commercial Zn show peculiar features shown in both the samples examined. A sudden increase in the temperature coefficient occurs at 220° C., and the resistance attains a well-marked maximum at 300°–310° C., after which it falls rapidly to 350°–380° C. Though the presence of impurities (Pb, Fe, and As) plays a large part in causing these irregularities, the author considers them to be intimately connected with the allotropic changes occurring in the pure metal. The brittle nature of Zn at 205° C. was probably observed in a commercial sample and stands in close relationship with the increase of resistance occurring at this temperature. The results are in general agreement with the theory of metallic conductivity: two allotropic modifications of an element possess the same resistance at the critical point, a discontinuity occurring only in the temperature coefficient. Pure Zn has a resistivity of 6·01 microhms at 16° C., the value for commercial Zn being 6·3 microhms. F. C. A. H. L.

133. *Thermo-elements.* **W. P. White.** (Phys. Rev. 31. pp. 135–158, Aug., 1910.)—(1) The e.m.f. of a thermo-element, whether homogeneous or not, can be expressed as equal to $\int H d\theta$ ($H =$ thermoelectric power, $\theta =$ temperature). Thus the effect of each portion of a thermo-element is proportional to the magnitude of the temperature gradient in which it lies; hence the vital parts of a thermo-element are the parts along which the temperature varies; they mainly determine the calibration and the constancy. In changing them (as by varying the depth of immersion in a furnace) the thermo-element itself is changed, if not homogeneous, while alterations in regions of uniform temperature-distribution, as at the junction, have little effect on the temperature measurement. (2) Commercial constantan wire good enough to make thermo-elements accurate to about 0·05 per cent. is easily obtained, but cannot be relied upon without any test for possible inhomogeneity. Compensated thermo-elements of higher accuracy, reading consistently to 0·0001 deg., for use at ordinary and low temperatures, can be made in a day or two each. Improvement in the accessory apparatus has shown that their constancy is about 10 times that shown 3 years ago. (3) The accuracy of 0·0001 deg. reached by the thermo-element can also be attained in its auxiliary apparatus (potentiometer, &c.). The resulting accuracy, both absolute and relative, and the sensitiveness are quite comparable with those of the best resistance thermometers yet used. (4) For the measurement of single temperatures the resistance thermometer is often more convenient. On account principally of the comprehensiveness of the potentiometer and its indifference to external contact resistances the thermo-element is usually preferable where several different measurements are to be made at once. The thermo-element is also usually superior for differential measurements, and its advantages in this respect can be made available for calorimetric work by the substitution of a suitable comparison body for the usual ice bath. (5) A very convenient wire-tester, a simple bath for testing and comparing thermo-elements, and a convenient form of tabulation for calibration curves are described. J. J. S.

134. *Electric Conductivity and Thermoelectric Force of Heusler's Alloys.* **F. A. Schulze.** (Deutsch. Phys. Gesell., Verh. 12. 20. pp. 822–823, Oct. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept.

22, 1910. Phys. Zeitschr. 11. pp. 1004–1005; Discussion, p. 1005, Nov. 1, 1910.)—The research dealt with in this paper forms part of a complete investigation of the physical properties of Heusler's alloys, the magnetic properties of which are being investigated by E. Take. The alloys were in Heusler's research first heated to about 600° C., and then quenched in cold water. The conductivity was measured by the method of Matthieson and Hockin, all results being for mean summer temperature. The thermoelectric force was measured against Cu, one junction being in melting ice, the other in water at 40 to 50° C. In the present research the alloys were heated after the quenching to various temperatures, then slowly cooled, and the electric conductivity and thermoelectric force determined after different long times. The temperatures of heating varied from 140 to 300° C. The qualitative results are as follows: The electric conductivity increases with increased alteration period up to a max. value which is about 1½ times the initial value. In general, the change is quicker the higher the temperature; *e.g.*, the end value for 140° is reached after about 250 hours, while for 300° only about 7 hours is required. There was, however, a somewhat long rate of change about 225°; it was slower for this temperature than for 140°. The thermoelectric force likewise increases with increased alteration temperature below about 200° C., and with increased alteration period reaches almost double the initial value. The connection between the conductivity and the thermoelectric force seems to be very close, for the latter decreases for temperatures over 200° C., reaching a minimum at 225° C., and then increases again up to about double the initial value as before. A. W.

135. *Thermal Forces of Solid Metal Solutions and the Law of Schenck.* **A. L. Bernoulli.** (Ann. d. Physik, 33. 4. pp. 690–706, Oct. 25, 1910.)—The author makes a series of experiments to test the law of Schenck, and finds it to be confirmed in the case of the dilute solid metal solutions used, viz., the solvent silver having small quantities of thallium or tin; cadmium dissolving 5 or 10 per cent. of mercury; copper dissolving small quantities of tin or zinc or up to 17 per cent. of nickel. In all the cases tested, at the hot junction the alloy was positive to the pure solvent as theory anticipated. [See Abstracts Nos. 2110 (1909) and 978 (1910).] E. H. B.

136. *The Platinum-Rhodium Thermo-element.* **R. B. Sosman.** (Amer. Journ. Sci. 30. pp. 1–15, July, 1910.)—In continuation of recent work from the Geophysical Laboratory in Washington on the nitrogen thermometer from Zn to Pd [see Abstract No. 400 (1910)], the interpolation curve of the thermo-element Pt—90 Pt–10Rh has been extended downwards to 0° and upwards to the melting-point of Pt, 1755°. Various fixed points were obtained from the boiling-points and melting-points of standard substances. The value for the melting-point of Pt, obtained by extrapolation of the curves of thermo-elements with from 1 to 15 per cent. of Rh, confirms the value 1755° within the estimated limit of 5°. A method of interpolating temperatures with the 10 per cent. thermo-element by means of a standard curve and deviation curves is described. The variation of thermo-e.m.f. with the temperature and composition of the alloy wire is exhibited graphically. The variation both with temperature and with composition is, within the limits of error, continuous over the entire range studied. A diagram is given showing the variation of thermoelectric power, *de/dt*, with the temperature and composition of alloys of Pt and Rh. The data indicate the formation of solid solutions, but no compounds, from 0 to 55 atomic per cent. of Rh. J. J. S.

137. *Calibration of Copper-Constantan Thermo-elements.* **W. P. White, H. C. Dickinson, and E. F. Mueller.** (Phys. Rev. 31. pp. 159–164, Aug., 1910.)—A pair of copper-constantan thermo-elements for use in calorimetric work was calibrated by comparison with resistance thermometers to an accuracy of 0·004°. A cubic equation probably represents the relation between temperature and e.m.f. in the interval 0 to 100°, with an accuracy of at least 0·005°. New thermo-elements may be very conveniently calibrated by direct differential comparison with those whose calibration is already known. J. J. S.

138. *Measurement of the Peltier E.M.F.* **H. C. Barker.** (Phys. Rev. 31. pp. 321–328, Oct., 1910.)—Two Dewar flasks containing paraffin oil, and thermally similar in every respect when at a common temperature, contained the junctions of five Cu-Ni couples through which a current was passed. Two similar heating coils were placed in the flasks in order that, with the heating current in one sense through the thermo-couples, a compensating current could be employed in one flask to keep its temperature as high as that of the other flask. It is shown that if a and b are the resistances of the heating coils, i_a and i_b the compensating currents in these, n the number of junctions in either flask, and i the current through each junction, P the Peltier e.m.f., is given by $P = (ai_a + bi_b^2)/4ni$. The mean value found was $6·75 \times 10^{-3}$ volt at 28·7°. Jahn found $5·08 \times 10^{-3}$ volt at 0°, and Czermak, $8·04 \times 10^{-3}$ at 19°. [See also Abstract No. 1083 (1907).] G. E. A.

139. *Electrical and Mechanical Properties of Alloys of the Noble Metals.* I. **W. Geibel.** (Zeitschr. Anorg. Chem. 69. 1. pp. 38–46, Nov. 15, 1910.)—The author has investigated the electrical properties and tensile strengths of alloys of the noble metals drawn into wire 0·1 mm. diam., the electrical properties determined being, electrical conductivity, temperature-coefficient between 0 and 160° C., and e.m.f. against a wire of pure Pt between 100 and 1000° C. The results obtained on the Pd-Au series are described in detail and the results are plotted against composition as ordinates. In general outline the curves indicate a continuous series of solid solutions, but the maximum on the strength curve at 56 atoms per cent. Au, does not correspond with either the minimum on the conductivity curve at 85 atoms per cent. Au or on the temperature-coefficient curve at 45 atoms per cent. Au. The addition of Au to Pd rapidly increases the e.m.f. against Pt, and it is interesting to note that the e.m.f. of a 60 per cent. Au alloy against Pt is four times that of a Pt — Pt-Rh couple. F. C. A. H. L.

140. *Compensation of Capacity in Large Resistances.* **E. Orlich.** (Deutsch. Phys. Gesell., Verh. 12. 22. pp. 949–954, Nov. 30, 1910. Communication from the Physikal.-Techn. Reichsanstalt.)—Instead of the Chaperon system of winding, the resistance is wound in two portions with a gap between them. The variation of induction and capacity with variation of the gap enables the gap (*i.e.*, the distance between the inner and outer portions) to be chosen so as to make the residual capacity very small. In a table of results given by the author, two resistances of 20,000 ohms each, wound by the Chaperon system, have residual capacities of 40 and 88×10^{-12} farad respectively, and a coil of 25,000 ohms wound in the new way has a residual capacity of 18×10^{-12} farad. F. E. S.

141. *Non-inductive Low-resistance Standard, or Shunt.* **C. V. Drysdale.** (Electrician, 66. pp. 341–348, Dec. 9, 1910.)—The form of resistance described

has been devised with special reference to the alternate-current potentiometer, where phase-measurements are made simultaneously with p.d. or current measurements, but it is equally suitable for ordinary shunts. The resistance is made by cutting the electrodes into a number of thin strips or fingers, which intercalate with one another, thus reducing the inductance to a very small figure. The inductance of such an arrangement can be approximately calculated with ease. F. E. S.

142. *An Absolute Induction Dynamometer.* **A. Semiller.** (Ann. d. Physik, 33. 2. pp. 414–430, Aug. 30, 1910. Extract from Dissertation, Berlin, 1909.)—The instrument consists of two rectangles of 0·145 cm. diam. silver wire. The outer, which can be rotated by hand on a scale of degrees, is of dimensions 7 cm. × 5 cm., and is traversed by the high-frequency current to be measured. The inner, of dimensions 6 cm. × 4 cm., is suspended by two silk fibres, and carries a mica damping plate and a concave mirror. A current of air can be sent from either of two rubber tubes against the mica plate in order to bring the inner rectangle quickly to rest. The theory of the instrument is investigated, and the various constants required are calculated. Experiments are made to test the accuracy of the formulæ used ; first with constant current to check the formula giving the rate of change of mutual inductance of the coils with the angle between them, and second, to test the influence of frequency. In these experiments the current is kept constant by a photometric method. The current passes through a 2-volt Osmium lamp and illuminates a screen ; a second screen is illuminated by a standard source, and the screens are viewed simultaneously through a double prism. The source of the current is a Poulsen oscillating circuit. Good agreement is found for wave-lengths from 350 to 1050 m., and also for longer waves of 19,000 and 32,700 m. For current from an alternator at frequencies from 30 to 56 per sec. the instrument is not sensitive enough for good accuracy to be obtained. Reference is made to the dissertation for a discussion of the cases other than when the instrument is used with steady deflection and with sinusoidal current. H. W. M.

143. *Galvanometer for Alternate-current Circuits.* **W. E. Sumpner** and **W. C. S. Phillips.** (Phil. Mag. 20. pp. 309–319, Aug., 1910. Paper read before the Physical Soc., June 10, 1910. Electrician, 65. pp. 482–483 ; Discussion, p. 483, June 24, and pp. 911–913, Sept. 9, 1910. Abstract.)—The authors describe a reflecting instrument for measuring alternating current. It is a moving-coil galvanometer in which the field is due to an electromagnet excited from an alternating source. The magnet core is built up of stampings, and has three windings, of 200, 2000, and 4000 turns, so as to give varied sensitivity. If a voltage V be applied to a winding of m turns, the core flux N is given by the equation $V = rA + mN$, where r is the resistance of the winding, and A is the current through it. For the frequencies used, r may be neglected in comparison with the reactance, and consequently the rate of change of N is directly proportional to V. A magnet is thus obtained, the strength of which at every instant is determined by the applied voltage. In its use as a voltmeter a voltage V is applied to a field winding of m turns, and another winding of n turns is connected through a condenser K to the moving coil. The torque is then proportional to $Kn(V/m)^2$. Owing to the shape of the gap and the small angle through which the coil turns, the induction density in the gap does not vary appreciably with the position of the moving coil. In its use as a null instrument in the alternating-current

bridge for comparing capacities and inductances, the alternating voltage V applied to the field coil of the instrument also causes the current A to flow through the bridge conductors, and the moving coil is connected directly across the bridge. V and A are brought into phase by means of a non-inductive resistance in the alternator circuit. The precautions which must be taken to ensure accurate results are discussed, and examples are worked out in illustration. The instrument is especially suitable for the measurement of small capacities. H. W. M.

ALTERNATING CURRENTS AND MAGNETISM.

144. *Properties of Two Powerful Straight Electromagnets.* **H. Ollivier.** (Annal. Chim. Phys. 21. pp. 289–322, Nov., 1910.) — Description of the construction and properties of two identical electromagnets, of which the cores were horizontal cylinders 10 cm. in diam. and 150 cm. long, placed end to end and carrying 4680 turns of thick wire. With a current of 30 amps., the field between the poles was 45,000 gauss. The reluctance of the air-space varied slightly, that of the iron largely, with the magnetising current; and when the cores were well magnetised, the air-space completed the magnetic circuit as well as it can be done by a return circuit of iron.

G. E. A.

145. *Mechanical Stress and Magnetisation of Iron.* III. **W. Brown.** (Roy. Dublin Soc., Proc. 12. 36. pp. 480–499, Sept., 1910.)—In the first and second parts of this paper the results were given of experiments with soft-iron wires in which the longitudinal magnetism, the circular magnetism, the longitudinal load, and the cross-sectional area of the wires were varied [see Abstract No. 1615 (1909)]. The results given in the present portion of the paper were obtained with iron wires of different tempers, or different degrees of magnetic softness, different lengths, and different diams. Five different degrees of hardness were adopted which were obtained by heating the wires to a cherry-red heat by means of a broad Bunsen burner when they were hung vertically and subjected to different longitudinal loads. The different degrees of hardness are indicated by the symbols H_0, H_1, &c. Swedish charcoal iron was used similar to that in the previous experiments. With the soft-iron wire of hardness H_0 when placed in a longitudinal magnetic field of 2·5 units the twist of the free end is inversely proportional to the load on the wire, and when the load is *increased* six times the twist is *decreased* 27 per cent. In all the three states of hardness H_0, H_1, and H_3 the twist of the free end is proportional to the length of the wire, and when the length of the wire is halved both the area of the cyclic curve in a field of 2·5 units and the twist are decreased 50 per cent. Also in the three cases the twist is inversely proportional to the load on the end of the wire, and the harder the wire the more the twist is diminished as the load is increased. On increasing the load 6 times, the twist is decreased 32 per cent. in the wire of hardness H_1, and 38 per cent. in the wire H_3, *i.e.*, increased load has more effect on a hard wire than on a soft one. When the curves relating to load and twist in the three tempered wires H_0 to H_3 are produced, they all cut the axis of abscissæ at points approximately equivalent to the elastic limit of the wire. The twist diminishes as the simple rigidity increases and also as the load increases. When the hardness is increased from H_0 to H_3 the twist is decreased 16, 22, and 29 per cent. respectively, when the loads on the wires were 0·5, 1·5, and 3·0 × 15^5 gm. per $cm.^2$ When the wire becomes harder, as the length of the wire is decreased and the load on it increased, the twists gradually approach the same value as the surrounding longitudinal magnetic field is increased. In wires of different degrees of magnetic softness the longitudinal magnetic field in which the max. twist occurs is independent of the load on the end of the wire between certain limits. With iron wires in the same physical state but of different diams., the max. twist occurs in longitudinal magnetic fields of different strengths—the thicker the wire the higher is the magnetic field in which the max. twist occurs. In a magnetic field of 3 units the twist is *doubled* when the cross-sectional area of the wire is *increased nine times*. The magnitude of the longitudinal magnetic field in which the max. twist occurs is directly proportional to the current density in the wire. With a given load on the wire and a given current through it, the twist in a given longitudinal magnetic field is inversely proportional to the cross-sectional area of the wire, or directly proportional to the current density in it. J. J. S.

146. *Magnetic Permeability of very Pure Soft Iron.* **B. O. Peirce.** (Amer. Acad., Proc. 46. No. 9. pp. 207–212, Oct., 1910. Contribution from the Jefferson Phys. Lab., Harvard Univ.)—The paper gives an account of ballistic tests on two specimens of very pure soft iron. One, a piece of Norway iron, was free from Ni, Co, W, and Mn, and had less than 0·03 per cent. C, 0·047 P, 0·03 Si, and 0·003 per cent. S. In low fields it was remarkably magnetic, giving a max. value of $\mu = 5480$ for $H = 1{\cdot}40$. With $H > 6$ gauss it was, however, less permeable than good iron should be. The results are compared with values obtained by other experiments for pure iron. A. D. R.

147. *Magnetic Permeability.* **R. Gans.** (Deutsch. Phys. Gesell., Verh. 12. 20. pp. 802–808, Oct. 30, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, Sept. 21, 1910. Phys. Zeitschr. 11. pp. 988–991; Discussion, p. 991, Nov. 1, 1910.)—If, when a specimen is under magnetic test and the applied field is being gradually varied, the process is stopped at any point and the field be now altered in the reverse direction by a small amount and restored, the secondary loop so formed is closed. The changes ΔB in B (or ΔI in I) consequent on the changes ΔH in H are equal in magnitude. Denote by μ_r the ratio $\Delta B/\Delta H$ and term it the reversible permeability, and similarly denote by κ_r the ratio $\Delta I/I$ which may be called the reversible susceptibility. The author has investigated the values of μ_r and κ_r for soft iron, for annealed and hardened magnet-steel, and for nickel. He finds that μ_r and κ_r do not depend on whether the test is made at a point on the initial magnetisation curve or on the ascending or descending branches of a main hysteresis loop, so long as the values of I are the same. μ_r and κ_r depend therefore only on the intensity of magnetisation of the specimen. Further, if we plot log $4\pi\kappa_r$ against log I, the resultant curves for various materials are congruent and may be made identical by employing different scales in the different cases. This may be expressed as follows: $\kappa_r/\kappa_0 = \phi(I/I_0)$ where κ_0 and I_0 are two constants of the material, and ϕ is a universal function. If we choose ϕ so that the function has the value unity for zero value of the argument, then κ_0 is the initial susceptibility and I_0 is the saturation intensity. Let $\kappa_r/\kappa_0 = y$ and $I/I_0 = x$, then $y = \phi(x)$ in which form the law is similar to a well-known law in the theory of gases. A. D. R.

RADIOLOGY AND ELECTRO-PHYSIOLOGY.

148. *Production of Röntgen Rays of Constant Intensity.* **G. Rümelin.** (Phys. Zeitschr. 11. pp. 908–909, Oct. 15, 1910.)—Since, on working a Röntgen-ray tube, the pressure falls, the rays change. Hence, to keep the rays constant, the author has an arrangement of continuous pumping which keeps the exhaustion constant. The details are explained by aid of a diagram. E. H. B.

REFERENCES.

149. *Theory of Electromagnetic Phenomena in Moving Bodies.* **J. Ishiwara.** (Mathematico-Physical Soc., Tōkyō, Proc. 5. 18. pp. 310–327, July, 1910.)—A highly analytical discussion of this subject on modern lines. [See Abstracts Nos. 2091 and 2123 (1909).] E. H. B.

150. *Propagation of Light in Moving Media.* **J. Ishiwara.** (Mathematico-Physical Soc., Tōkyō, Proc. 5. 18. pp. 327–333, July, 1910.)—A mathematical treatment on the electron theory in which reference is made to the mechanics of G. N. Lewis and R. C. Tolman [see Abstracts Nos. 1486 and 1488 (1909)]. E. H. B.

151. *Electromagnetic Phenomena in Moving Bodies.* **A. Szarvassi.** (Akad. Wiss. Wien, Sitz. Ber. 119. 2a. pp. 231–336, March, 1910.)—A discussion by vector analysis of the principle of the conservation of energy applied to electromagnetic phenomena in moving bodies. E. H. B.

152. *Application of Thermodynamics to the Electron Theory of Thermo-electricity.* **F. Krüger.** (Phys. Zeitschr. 11. pp. 800–808, Sept. 15, 1910.)—A theoretical discussion which is largely mathematical. [See Abstracts Nos. 2199, 2200 (1900), and 1443 (1906).] E. H. B.

153. *Remarks on Recent Researches on Canal Rays.* **J. Stark.** (Deutsch. Phys. Gesell., Verh. 12. 19. pp. 711–718, Oct. 15, 1910.)—This is a theoretical paper dealing with the observations of Paschen, Stark and Steubing, and Strasser [see Abstracts Nos. 1348 (1907), 1085 (1909), 905 (1910)] on canal rays, in particular the fact that two maxima are found to exist in the Doppler-effect obtained with canal rays in hydrogen, and the phenomena connected therewith. Some recent work of H. v. Dechend and W. Hammer is also fully discussed. A. E. G.

154. *Arrangement for Direct Photographic Observation of Canal Rays in Pure Gases.* **J. Kœnigsberger.** (Phys. Zeitschr. 11. pp. 848–850, Oct. 1, 1910.)—A detailed account is given of the means used for obtaining photographs due to canal rays. Velox paper is used for this purpose. The methods by which absolute freedom from hydrogen as an impurity in the gases used is obtained are fully described, and a diagram showing the arrangement of the complete apparatus is also given. A. E. G.

155. *Observations on Canal Rays.* **J. Kœnigsberger** and **K. Kilchling.** (Deutsch. Phys. Gesell., Verh. 12. 22. pp. 995–1017, Nov. 30, 1910.)—An account of experiments carried out by the previously described photographic method [see preceding Abstract] is here given under the following sectional headings: (1) The method; (2) Variations of the canal rays due to collisions (dissociation, neutralisation, decrease of velocity and deflection); (3) Dissociation in hydrogen; (4) Canal rays in a high vacuum, with short paths in the discharge space; (5) Influence of mercury vapour and CO_2 on the canal rays; (6) Some influences of the canal rays; (7) Influence of the kathode and tube on the canal rays; (8) Place of origin of the canal rays. A large number of illustrations are given which show the photographic appearances obtained under various conditions. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

156. *Absorption of Radium Emanation by Cocoanut Charcoal.* **J. Satterly.** (Phil. Mag. 20. pp. 778–788, Oct., 1910.)—The experiments described deal with the absorption of RaEm by cocoanut charcoal, the emanation being carried to the charcoal by a stream of air which had previously passed through a solution of Ra. For solutions containing amounts of Ra up to 6×10^{-9} gm. with a 2¼ hours' exposure and an air current of 0·5 litres per min., the amount of emanation absorbed by the charcoal was found to be proportional to the Ra-content, but for stronger solutions and greater times of exposure a saturation effect was found, the tubes used being 60 cm. long, 1·6 cm.^2 cross-section, and containing 89 gm. charcoal. Under the same conditions of experiment the amount of emanation absorbed was found to be independent of the humidity of the air. A quantitative experiment showed that with tubes 8 cm.^2 in. cross-section, containing a column 30 cm. long of coarsely powdered cocoanut charcoal, the amount of emanation absorbed with an air stream of 0·5 litre per min. passing through a solution containing $0{\cdot}6 \times 10^{-9}$ gm. Ra for 21 hours, was only about 62 per cent. of the total amount of emanation carried by the air. With air streams of magnitudes 0·11, 0·25, 0·80 litre per min., the amounts of emanation caught were 86, 73, and 23 per cent. respectively.

E. M.

157. *Eosin-reaction of Fractured Glass Surfaces.* II. *Weathering* [*Devitrification*] *of Hard Glasses.* **F. Mylius.** (Zeitschr. Anorg. Chem. 67. 2. pp. 200–224, July 28, 1910. Communication from the Physikal.-Techn. Reichsanstalt.)—Devitrification of glass includes efflorescence due to various causes, corrosion, and absorption or removal of water. The subject is dealt with under the following headings: (1) *Material of the Glass and Micro-chemical Tests* [see Abstract No. 865 (1910)]. (2) *Glass and Iodeosin.* The adsorption of eosin from ethereal solution is due to the basic constituents of the glass (potash, soda, lime, magnesia, baryta, and lead and zinc oxides), but not to silica or boric acid; the action of alumina is slight. Eosin is absorbed slowly by pure lead silicate, but rapidly by the alkaline salt. With hard (lead silicate) glasses, in spite of their slight tendency to weathering, the eosin reaction increases considerably with the duration of immersion, and is hence not proportional to the weathering. (3) *Weathering.* The weathering of hard glasses (in air saturated with water-vapour at 18°) is mostly accompanied by retrogression of the natural alkalinity, this coming to a stop after about a week. (4) *Investigation of different Glasses.* (5) *Influence of the Composition.* Natural alkalinity and alkalinity after weathering are constant values depending on the chemical composition of the glass. Weathering is increased by increase of the alkali-content, whilst the stability of the glass is augmented by raising the proportion of lead, baryta, or zinc oxide. T. H. P.

158. *Preparation of Fused Tungsten.* **L. Weiss** [with **A. Martin** and **A. Stimmelmayr**]. (Zeitschr. Anorg. Chem. 65. pp. 279–340, 1910.)—Experiments on the preparation of tungsten by the aluminothermic reduction of wolframite are first described, resulting in a product containing up to 90·66 per cent. W. Another method consists in the electrolysis of tungstic acid mixed

with cryolite, the tungstic acid being prepared by fusing wolframite with calcium carbonate and calcium chloride and decomposing the product with acid. The metal obtained in this way consists of globules only and contains 96 per cent. W. The best result, a metal containing 98·96 per cent. W, is obtained by fusing tungsten trisulphide with lime in a graphite crucible by means of the arc. When fused in a hydrogen vacuum, tungsten is white in colour and metallic-looking; its hardness is 6·5–7·5, and density, at 20°, 18·72; small pieces can be hammered out, but the malleability is dependent upon the amount of heat treatment. Tungsten is non-magnetic; the specific heat is 0·0858, and the heat of combustion per gm. is 1047 cals. A mixture of nitric and hydrofluoric acids is the only reagent which is able to dissolve the fused metal; concentrated sulphuric and nitric acids and aqua regia only attack the surface very slowly. L. H. W.

159. *Fusion of Carbon by means of the Joule-effect.* **M. La Rosa.** (N. Cimento, 20. pp. 802–812, Oct., 1910.)—A current of about 60 amps. at 150 volts has been passed through carbon rods of 1, 2, and 8 mm. diam., and containing only 0·07–0·08 per cent. mineral matter. If the full current is passed directly through the rod, explosion takes place, but by gradually raising the current by reducing the resistance, the carbon becomes luminous, and bends slightly. By enclosing the carbon in a porcelain tube, and then producing an explosion, stains are found on the sides of the tube, which, examined microscopically, are apparently carbon. Though no complete liquefaction or crystallisation of carbon has taken place, the results obtained are considered to indicate incipient fusion. [See also Abstracts Nos. 688 and 2156 (1909).] W. H. St.

160. *Ternary Alloys of Copper, Antimony, and Bismuth.* **N. Parravano** and **E. Viviani.** (Accad. Lincei, Atti, 19. pp. 848–849, Oct. 2, 1910.)—The authors continue their thermo-analytical investigation of these alloys, determining the temperatures of solidification and transformation of some 22 alloys of the system Cu_3Sb-Cu-Bi, and plotting their positions on thermo-diagrams. Microphotographs of some of the alloys are given. The limits of miscibility of Cu_3Sb-Sb-Bi, and Cu_3Sb-Cu-Bi, in the liquid state, have been determined by maintaining mixtures of these in a porcelain crucible for some time at about 670° C., and analysing the layers which separate. [See Abstracts Nos. 1541 (1910) and 188 (1911).] W. H. St.

161. *Silver-Cadmium Alloys.* **G. Bruni** and **E. Quercigh.** (Zeitschr. Anorg. Chem. 68. 8. pp. 198–206, Oct. 12, 1910.)—A consideration of the cooling curves of thirty of these alloys shows that they can be divided into two series—those containing 0–80 atoms per cent. Cd and those containing 80–100 atoms per cent. Cd. Alloys containing 0–80 atoms per cent. Cd form a continuous series of solid solutions, of which, alloys containing 50 and 80 atoms per cent. Cd solidify at constant temperatures at 712° C. and 545° C. respectively, pointing to the existence of the two compounds AgCd and $AgCd_4$. $AgCd_4$ undergoes a polymorphic change at 488° C., a change which does not appear to be common to the alloys on either side of it. Between 80 and 100 atoms per cent. Cd the solidification curve consists of two branches, a steep portion to 345° C. at 97 atoms per cent. Cd, after which the curve falls less steeply to the solidification point of Cd. From 87–100 atoms per cent. Cd the alloys consist of a single solid solution which solidifies over a somewhat wide range of temperature, while between 80 and 87 atoms

per cent. Cd the alloys consist of a conglomerate of the compound $AgCd_4$ and the solid solution containing 86 atoms per cent. Cd. The results have been confirmed by microscopic examination of the alloys, and agree in general outline with those of Kirke-Rose [Abstract No. 452 (1905)]. F. C. A. H. L.

162. *Alloys of Tellurium with Cadmium and Tin.* **M. Kobayashi.** (Coll. Sci. and Engin. Mem. Kyōto, 2. 11. pp. 358–368, Oct., 1910. Zeitschr. Anorg. Chem. 69. 1. pp. 1–9, Nov. 15, 1910.)—The methods of thermal analysis have been applied to these systems with the following results. Tellurium-cadmium give rise to an equilibrium curve which rises from the melting-point of Cd (322° C.) to a maximum at about 1042° C. corresponding to the formation of a compound TeCd, and then falls to the melting-point of Te (437° C.). On account of the high melting-point of the compound and the volatility of Cd, no observations of the beginning of solidification of alloys containing between 1·2 and 55·17 per cent. Te could be obtained. The compound does not form solid solutions with either of the constituent metals, and the two eutectics consist of the practically pure metals. Tellurium-tin give rise to a compound TeSn which solidifies at 780·5° C. One eutectic consists of practically pure Sn, while the other contains about 86 per cent. Te and solidifies at 398° C. The compound TeSn forms greyish-coloured crystals of sp. gr. 6·472. It dees not form solid solutions with either of the constituent metals. Seven photomicrographs illustrate the paper. F. C. A. H. L.

163. *Tellurides of Sodium.* **G. Pellini** and **E. Quercigh.** (Accad. Lincei, Atti, 19. pp. 350–356, Oct. 2, 1910.)—By warming together sodium and tellurium in a quartz tube in an atmosphere of nitrogen, compounds have been obtained corresponding to the formulæ Na_2Te, Na_3Te_2, and Na_3Te_7, the existence of which is also confirmed by thermal analysis. The compound Na_2Te_2 is not formed by this method. W. H. Si.

164. *Tellurides of Silver.* **G. Pellini** and **E. Quercigh.** (Accad. Lincei, Atti, 19. pp. 415–421, Oct. 16, 1910.)—Thermo-analysis of alloys of Ag and Te shows the formation of compounds corresponding to the formulæ AgTe and Ag_2Te. The former is produced at 444°, is decomposed at higher temperatures, and polymerises at 412°; the latter melts without decomposition at 959°, and undergoes no polymerisation. W. H. Si.

165. *Production of Cementation Steel.* VII. *Process based on Specific Action of Carbon Monoxide.* **F. Giolitti** and **G. Tavanti.** (Accad. Sci. Torino, Atti, 45. 11. pp. 849–873, 1909–1910.)—Examination of numerous cases of fracture in steel, microphotographs of one of which are given, leads to the conclusion that such flaws are due to irregular distribution of carbon, brought about by separation of ferrite during the slow cooling of the steel after cementation. This can be sometimes obviated in the ordinary cementation process by suddenly cooling, but more generally by carburising with CO. To obtain concentrations of more than 0·3–0·4 per cent. carbon with the latter, it must be either mixed with a small quantity of reducing gas, *e.g.*, hydrocarbons, or, better, employed in the presence of free carbon. Examples are given, illustrated by microphotographs, of the application of this latter process, on the laboratory scale, to a steel containing C, 0·14; Si, 0·03; Mn, 0·80; S, 0·05; and P, 0·02 per cent. respectively, the steel being inserted in a porcelain tube, packed with either granular or powdered wood-charcoal, and heated to 1000–1200° C. in an Heraeus furnace, the CO being produced by passing CO_2 over similar hot charcoal before it reaches the steel. Cementation takes place to a considerable depth without formation of any cementite, and the depth of the hypoeutectic zone is at least 50 per cent. of the total depth of cementation. The rate of carburisation is greater with granular than with powdered carbon, showing that the process depends more on the action of CO than on intimate contact between the carbon and steel. Microscopical examination of pieces of carburised steel, subjected to the action of CO for 7 hours at 1000° in one case, followed by another 8 hours at 1000°, shows the value of CO in promoting diffusion of the carbon, the total thickness of the cementation zone being increased from 4·2 to 6·0 mm. in the former case, and from 4·8 to 8·5 mm. in the latter. [See Abstracts Nos. 1546, 1547 (1910).]

W. H. Sı.

166. *Influence of Sulphur on the Iron-Carbon System.* **T. Liesching.** (Metallurgie, 7. pp. 565–571, Sept. 22, 1910.)—Starting from Swedish charcoal iron (3·8 per cent. C.), Swedish wrought iron, and a puddled iron, all of great purity, and an iron sulphide containing 28 per cent. S, the author has prepared 46 alloys, containing 0·08 to 4·78 per cent. C and 0·01 to 1·11 per cent. S. Cooling curves of all the alloys were taken, after which they were subjected to chemical and micrographic analysis. Certain irregularities in the temperatures at which freezing commenced were observed, and ascribed to an increased tendency towards supercooling. Sulphur lowers the freezing and eutectic temperatures of the iron-carbon system, but leaves the pearlite arrest-point unchanged. Difficulties were at first met with in obtaining a satisfactory method of etching, the method ultimately adopted being to etch lightly in a 4 per cent. solution of picric acid in amyl alcohol, then in 4 per cent. nitric acid in amyl alcohol, and finally immersing in hot concentrated caustic soda, which colours the sulphide areas brown without affecting the structure developed by the acids. Ziegler's observation that the constituent solidifying at 970° C., and usually seen as a homogeneous grey mass, is really a eutectic of Fe and FeS containing about 31 per cent. S is confirmed. In alloys containing 0·24 per cent. carbon the sulphide forms a network larger than the general ferrite network which subdivides the larger structure outlined by the sulphide eutectic. Sulphide separations never take place in the pearlitic areas. Attempts to prepare alloys containing over 2 per cent. S showed that the alloys with high carbon-content separated into two conjugate layers, the upper layer containing 26 to 28 per cent. S and 0·22 to 0·32 per cent. C, and the lower layer 2·05 to 2·25 per cent. S and 3·04 to 3·43 per cent. C.

F. C. A. H. L.

167. *Electrical Purification and Electrical Conductivity of Liquid Sulphurous Anhydride.* **J. Carvallo.** (Comptes Rendus, 151. pp. 717–719, Oct. 24, 1910.)—Liquid sulphur dioxide in a sealed tube was exposed to the action of a p.d. of 2350 volts set up between two Pt discs 0·5 cm. apart. Initially this caused the passage of a current of 111×10^{-6} amp., but after 8 days the current fell to a constant value $0{\cdot}3 \times 10^{-6}$, the liquids being permanently purified by the passage of the current in much the same way as that already noticed by Jaffé in the case of hexane, and by Schröder in the case of ethyl ether. Up to a pressure of 100 volts the purified liquid obeys Ohm's law; beyond this the current increases at a slower rate, tending towards a constant value (*e.g.*, 0·480 at 2820 volts, 0·486 at 3760 volts); if the

voltage is increased beyond 5000 there is a sudden increase in the current, as if disruptive conditions were being reached. The steady resistance, below 100 volts, is $7·6 \times 10^9$ ohms/cm.—a figure 700 times greater than that observed by Walden for the liquid purified by ordinary methods; the greatly increased resistance of the liquid at higher voltages brings it into line with gases as regards its conducting properties, which thus differ entirely both from those of metals and from those of electrolytes. T. M. L.

168. *Reduction of Ferric Oxide by Solid Carbon.* **G. Charpy** and **S. Bonnerot.** (Comptes Rendus, 151. pp. 644–645, Oct. 10, 1910.)—To determine the effect of the gases ordinarily present in the cementation of iron, the author has measured the rate of reduction of ferric oxide by solid carbon under reduced pressure. Graphite and ferric oxide, carefully purified and heated to 1000° *in vacuo*, were intimately mixed and agglomerated, and then heated to 950° C. in an electric furnace under low pressures, the gas evolved being measured. The following results were obtained:—

Pressure, mm. Hg.	Cm.^{3} of Gas Evolved per Hour.	Pressure, mm. Hg.	Cm.^{3} of Gas Evolved per Hour.
0·01	0·10	2	0·56
0·1	0·14	4	0·80
1	0·31	8	1·07

The rate of reduction diminishes rapidly with decrease of pressure, and at a pressure of about 1/1000 mm. becomes practically zero. It is concluded that solid carbon does not itself reduce ferric oxide, at any rate up to 950° C.

W. H. Si.

169. *Nature of the Transition Layer between Two Adjacent Phases.* **W. C. McC. Lewis.** (Phil. Mag. 20. pp. 502–511, Sept., 1910.)—In a discussion of the transition layer between two adjacent phases, the author points out that the values for the internal pressure in a liquid, as obtained by the Bakker-Dupré method of calculation, are considerably larger than those calculated from van der Waals' equation; and to explain this he assumes that the density in the surface layer is greater than in the bulk of the liquid. A table is given showing the average values for the surface density of a number of liquids at the boiling-points. The variation of surface density of water with temperature and the temperature variation of the internal pressure, both in the bulk of the liquid and in the surface layer, are discussed and the results tabulated. The heat-effect involved in this density-change is calculated per unit area of surface and is found to be 0·0034 cal. This agrees approximately with the analogous determination of Parks. A. F.

170. *Absolute Sulphuric Acid as a Solvent.* **F. Bergius.** (Zeitschr. Phys. Chem. 72. 3. pp. 338–361, 1910.)—The molecular conductivity of various salts and acids dissolved in absolute sulphuric acid was found not to decrease regularly with increasing concentration, but to increase, decrease, or remain constant according to the nature of the solute. Solubility measurements showed that only the sulphates of the alkalies and alkaline earths are specially soluble in sulphuric acid, and that these form with the acid compounds which could in some instances be isolated. The anomalies in the conductivity of the solutions can be explained by means of the formation of complexes. T. M. L.

171. *The Ionisation Relations of Sulphuric Acid.* **A. A. Noyes and M. A. Stewart.** (Amer. Chem. Soc., Journ. 32. pp. 1133–1162, Oct., 1910. Contribution from the Research Lab. of the Mass. Inst. of Technology, No. 57.)—The following values were deduced for the concentrations of the different constituents of sulphuric acid :—

Mols. per Litre.	C_H/C.	$C_{H_2SO_4}/C$.	C_{HSO_4}/C.	C_{SO_4}/C.
	From conductance data at 0°.			
0·080	1·38	0·06	0·50	0·44
0·025	1·48	0·05	0·42	0·53
0·005	1·67	0·02	0·29	0·69
	From conductance data at 25°.			
0·080	1·25	0·06	0·63	0·31
0·025	1·33	0·05	0·57	0·38
0·005	1·62	0·02	0·34	0·64
	From freezing-point data at 0° C.			
0·080	1·22	0·06	0·66	0·28
0·025	1·32	0·05	0·58	0·37
0·005	1·59	0·02	0·37	0·61
	From isohydric data at 25°.			
0·080	1·17	0·06	0·71	0·23
0·025	1·28	0·05	0·65	0·30
0·005	1·65	0·02	0·31	0·67

This implies that at a concentration of M/200 2 per cent. of the acid is undissociated, 34 per cent. is dissociated into H and HSO_4, and 64 per cent. into 2H and SO_4, the corresponding percentages being at M/40 5 per cent., 50 and 39 per cent., and at M/20 6 per cent., 62 and 32 per cent. For solutions of sodium hydrogen sulphate at a concentration of M/10 the proportions deduced are—

C_{Na}/C 0·68, C_K/C 0·44, C_{HSO_4}/C 0·44, C_{SO_4}/C 0·34,
C_{NaHSO_4}/C 0·08, $C_{Na_2SO_4}/C$ 0·12, $C_{H_2SO_4}/C$ 0·02.

A novel method of estimating the hydrogen-ion concentration consisted in determining by experiment the relative concentrations of hydrochloric and of sulphuric acid which drive back the ionisation of picric acid to the same extent, the condition of equal ionisation of the picric acid being ascertained by shaking the aqueous solution with benzene, into which the un-ionised picric acid distributes itself. T. M. L.

172. *The Rusting of Iron.* **K. Arndt.** (Metallurgie, 7. pp. 627–637, Oct. 22, 1910.)—Referring to Schleicher and to Heyn and Bauer [see Abstracts Nos. 1128 (1909) and 1064 (1910)], who worked with water and aqueous solutions, the author conducts potential measurements on iron embedded in wet sand. He uses four kinds of iron, a cast iron and three mild steels, all in the shape of pipes, 8 cm. in diam.; from these he cuts rings of 5 cm. width, which are cut into four segments, partly paraffined and buried in sand, moistened with water from the mains. The potentials measured (method of Wilsmore) are those of the cast iron against the steels, and of the four materials against a calomel electrode; in the latter case the sand was moistened with 0·01*n* $CaCl_2$. Cast iron inclined less to rusting than steel in moist sand, and the rust formation was also less noticeable in the cast iron after it had been embedded for several weeks in sand containing 7 per cent. of water. Inclination to rusting and velocity of rusting have to be distinguished; the latter depends on surface conditions, &c. The potential of iron is rendered more noble (less negative) when the iron becomes covered with oxide; as the oxide coating is porous (Haber) the changes in the potential are gradual, not abrupt. The better the oxide coating covers the iron, the less the iron will rust, and as the rough surface of cast iron assumes a more adhesive rust coating, cast-iron pipes corrode less in moist sand than steel pipes. On the whole, high potentials and high corrodibility go together. H. B.

173. *E.M.F. Produced in Solutions by Centrifugal Action.* **R. C. Tolman.** (Amer. Acad., Proc. 46. No. 5. pp. 109–146, Sept., 1910. Contribution from the Research Lab. of the Mass. Inst. of Technology, No. 59.)—It has been shown experimentally by Des Coudres that an e.m.f. is set up owing to the action of gravity between two electrodes immersed at different heights in the same solution, this e.m.f. disappearing only when it has become balanced by a slow change in the concentration of the solution at its different levels. Des Coudres showed that a measurement of the e.m.f., coupled with a knowledge of the solution volume of the salt, could be used to calculate the Hittorf transport-number for the salt. An apparatus is now described, driven by a 80-h.p. steam turbine, whereby greatly increased e.m.f.'s can be produced by centrifugal force; this method had been used by Des Coudres, but in a much less efficient form. The rotator could be driven up to 7850 r.p.m., giving a peripheral speed of 50,000 ft. per min., but in practice this velocity was reduced to about one-tenth in order to avoid breaking the glass linings in which the solutions were placed. The e.m.f. measured was usually from 3000 to 6000 microvolts, and the probable error of the transport-numbers was of the order of 0·001. Very few transport-measurements have been made with the iodides used in the present investigation, but the chlorine ion has the same mobility, and comparison can therefore be made with previous observations on the chlorides as follows:—

TRANSFERENCE NUMBER OF THE ANION.

Halide of—	Iodide.	Chloride.	Iodide.	Chloride.	Iodide.	Iodide.
	Centrifugal.	Washburn, Buchböck.	Infinite Dilution.	Infinite Dilution.	Dennison.	Bein.
K	0·514	0·518	0·507	0·508	0·514	0·505
Na	0·615	0·634	0·604	0·601	0·624	—
Li	0·782	0·722	0·668	0·662	—	—
H	0·184	0·160	0·174	0·172	—	—

The agreement is quite satisfactory, except in the case of the acids, which gave an exceptionally small e.m.f. T. M. L.

174. *Formation of Nitric Oxide in the High-tension Arc.* **F. Haber, A. Koenig and E. Platou.** (Zeitschr. Elektrochem. 16. pp. 789–796, Oct. 1, 1910.)—The experiments were made as previously with cold arcs, produced in quartz tubes, provided with a water jacket. The best yields were, with direct current, obtained when the pressure was reduced to about 150 mm. of

Hg; they had formerly recommended a pressure of about 100 mm. At higher pressures the arc became thinner, receding more from the quartz walls. In the alternating-current experiments the phase-lag was determined by means of a binant electrometer; in this they follow Warburg and Leithäuser with whom they agree that the formation of NO may be essentially electrical and not thermal (Nernst). This conclusion is confirmed by the other researches recently carried out at Karlsruhe. The best yield, 500 kg. of HNO_3 per kw.-year at a concentration of 3·4 per cent. of NO, was slightly less than with direct current. The average phase-lag was 0·6. H. B.

175. *Formation of Nitric Oxide by High-frequency Discharges.* **F. Haber** and **E. Platou.** (Zeitschr. Elektrochem. 16. pp. 796–803, Oct. 1, 1910. Dissertation of E. Platou, Karlsruhe.)—Since energy determinations become very difficult with high-frequency discharges, the authors place the glass apparatus in a calorimeter, using Pt electrodes, bent like the horns of lightning arresters, and mercury contacts. The discharge tube stands in paraffin oil in a Dewar vacuum jacket. The gases pass on leaving through one or two silver tubes, charged with silver filings; one of these silver tubes of Eilhard Wiedemann sufficed, with the maximum velocity of the air current applied (114 litres per sec.) to reduce the temperature of the gases to the temperature of the bath. The calculations are made merely for the formation of NO, considering that the heat of formation (likewise negative) of the other nitrogen oxides would only amount to 2 per cent. of the whole. The Wehnelt interrupter yielded currents of frequency 500, the discharge circuit (after v. Lepel), currents of a frequency about 100 times as great. The yield of NO was with the higher frequency slightly worse than with the lower, and poorer also at diminished pressure (388 mm.) than at atmospheric pressure. This latter observation disagrees with the other experiments of Haber, while it would agree with the experiments of Briner and Durand. The authors consider, however, that the peculiarities of the discharges from electrodes of the horn type do not justify any general conclusions. H. B.

176. *Yield of Nitric Oxide with Cooled Direct-current Arcs.* **W. Holwech** and **A. Koenig.** (Zeitschr. Elektrochem. 16. pp. 803–810, Oct. 1, 1910.)—The arrangement is not that described in Abstract No. 1151 (1910). The discharge takes place in a vertical tube. The uncooled electrode (mostly the kathode) is an iron wire, 2mm. in diam., over the end of which a little quartz tube is pushed. The other electrode is a cylinder of copper, water-jacketed, ranging in diam. from 0·5 to 3 mm.; it is called the capillary in the paper. As the arc extended into and through this capillary, the length of the actual arc (electrode distance from 2 to 5 mm. about) was not definite. The yield rose to 75 gm. HNO_3 per kw.-hour at a concentration of about 2 per cent. of NO (max. 3·5 per cent.). Special heating of the kathode did not increase the yield much. The yield fluctuated when the capillary was placed above (instead of below) the other electrode. The yield was very satisfactory, 70 gm. NHO_3 being technically considered good; but the arrangement would hardly answer in technical practice. H. B.

177. *Formation of Nitric Oxide in Direct-current Arcs under Pressure.* **F. Haber** and **W. Holwech.** (Zeitschr. Elektrochem. 16. pp. 810–813, Oct. 1, 1910.)—The arrangement is that of Schönherr. The furnace consisted either of a single vertical steel tube, water-jacketed, and provided with three windows for observations; or of three concentric-shell tubes, through which

the air circulated so as to become preheated before entering the furnace proper; one window was provided in this case. Direct currents were exclusively tried. The yields were very good. As the loss in the series resistance was not considered, only a relative value is claimed for the results. The first arrangement (no preheating) gave a poor concentration of NO; both the yield and the concentration diminished when the air pressure was raised (to 20 atmos. maximum). The second arrangement (air preheated) gave somewhat better concentrations; but the yield did certainly not improve when the pressure was raised to 12 atmos. The air feed varied between 2500 and 3700 litres per hour, calculated for 0° and 760 mm. H. B.

178. *Seat of the E.M.F. of the Voltaic Cell.* **G. Guglielmo.** (Accad. Lincei, Atti, 19. pp. 496–501, Nov. 20, 1910.)—The author has examined the effect on a Daniell cell of the surface condition of the zinc pole. The poles of the cell were each connected by wires to tubes, 9 cm. long, and 4 cm. in diam., of the same metal as the pole, and fixed one on each side of a short glass tube of the same diam. One pair of quadrants of the electrometer was then earthed and also put in contact with one of the poles, the other pair being connected with the water in a Kelvin water-dropper. It is found that (1) when the zinc pole and tube are both polished with emery paper and not amalgamated, the potential inside the Cu tube is about ⅓ volt higher than that inside the Zn tube; (2) when the Zn pole only is amalgamated, this result is not appreciably affected; (3) if the Zn tube is amalgamated internally, the potential inside it is only about 0·03 volt less than that inside the Cu tube, whether the Zn pole is amalgamated or not; and (4) if both tubes are of either Zn or Cu, the p.d. between their interiors is the same as when the two poles are put directly in contact. It is concluded that the p.d. between the Cu and Zn of a Daniell cell on open circuit is very small, but depends on the state of the surface of the Zn in contact with the air, and that the internal p.d. between the poles of a voltaic cell cannot be determined by direct electrometric measurement. The thermodynamic theory, according to which the source of the e.m.f. is the contact between the two metals, is not confirmed. W. H. Si.

179. *Conditions affecting the Electrolytic Determination of Copper.* **W. C. Blasdale and W. Cruess.** (Amer. Chem. Soc., Journ. 32. pp. 1264–1277, Oct., 1910.)—"It seems probable that the relative efficiencies of the different forms of stationary electrodes depend entirely upon the extent to which they favour circulation of the electrolyte, and upon the equal distribution of the current density over the entire surface of the kathode." To obtain data upon these points the rates of precipitation of known amounts of copper under identical conditions, except as regards the electrodes used, were determined. Each solution used contained 0·1975 gm. of Cu as copper sulphate, 2 c.cm. of concentrated sulphuric and 1 c.cm. of concentrated nitric acid, and water to 140 c.cm. They were electrolysed with a practically constant current of 0·84 amp., and the Cu deposited during definite time-intervals was determined. The various kathodes used were: (A) A Classen dish which gave 120 cm.^{2} of available surface when it contained the 140 c.cm. of electrolyte. The anode was a disc of foil, 4·1 cm. in diam., with six radially distributed openings near its rim. (B) A cylinder of foil 2·5 cm. in diam. and 5 cm. in length, the effective area being 79 cm.^{2}. The anode was a cylindrical spiral of Pt-wire, the beaker containing the solution was 5·5 cm. in internal diam. (C) The same as (B), except that the kathode was pierced with 270 holes 1 mm. in

diam. (D) A gauze cylinder 8·2 cm. in diam. and 5·5 cm. in length, the wire of the gauze being 0·06 mm. in diam.; there were 41 meshes per linear cm. Available area, 98 $cm.^2$. Anode and beaker as in (B). (E) Kathode the same as (D). The anode consisted of a stout wire coiled to form a horizontal spiral, and was suspended at the bottom of the beaker. (F) Gauze cylinder 4 cm. in diam. and 4 cm. long, with 25 meshes per linear cm. The wire of the gauze was 0·1 mm. in diam., and the effective area 80 $cm.^2$. Anode and beaker as in (B). The results obtained are given in the form of curves, showing the relation between the time and the amount of Cu deposited. The gauze electrode (D) is the most efficient, and comparison of the results with (D) and (F) show that the efficiency increases with the fineness of the mesh. Piercing holes in the foil kathode (compare B and C) increases the efficiency. The cylindrical spiral anode is better than the horizontal disc (D and E). The times needed to deposit 0·1975 gm. Cu were 400, 450, 380, 50, 60, and 100 min. respectively with the kathodes A, B, C, D, E, and F. In the next set of experiments the gauze electrode D was used throughout; 140 c.cm. of the solution contained 0·1975 gm. Cu as copper sulphate, 2 gm. of ammonium nitrate, and 4 c.cm. of concentrated nitric acid. The currents used were 0·19, 0·34, 0·5, 0·78, and 5·5 amps. respectively. The higher the current the quicker is the Cu deposited. Quantitative deposits were obtained with the first four currents, but with 5·5 amps. the results were low, owing to the temperature attained (60°), which increased the solvent action of the nitric acid. Decreasing concentration of the electrolyte was found to increase the time of deposition, this increase being mainly due to the increased time necessary for the deposition of the last 10 per cent. of the Cu. An investigation of the effect of the addition of acids to the copper-sulphate electrolyte showed that with sulphuric acid spongy deposits are obtained when a Classen dish or foil kathode is used. In no case has a spongy deposit been obtained with gauze electrodes. In nitric acid solutions the temperature should not rise above 30°, otherwise Cu is dissolved; below this temperature the solution may contain as much as 4 c.cm. of acid per 140 c.cm. of solution. The presence of iron as ferrous sulphate, in a solution containing sulphuric acid, diminishes the rate of deposition of the Cu, but does not otherwise affect it. When ferric sulphate is present no Cu is deposited for a definite interval which is roughly proportional to the amount of ferric salt present. The time at which deposition begins is probably conditioned by the equilibrium $2Fe^{\cdot\cdot\cdot} + Cu \rightleftarrows Cu^{\cdot\cdot} + 2Fe^{\cdot\cdot}$. When the solutions contain low concentrations of both ferric and nitrate ions the rate of deposition is merely retarded, but where either of these factors, especially the nitrate concentration, becomes large, deposition may take place normally up to a certain stage, after which rapid re-solution of the Cu takes place. Special experiments showed that this re-solution is probably due to the formation of nitrous acid, and that neither nitric nor sulphuric acid, nor ferric salts are the effective agents concerned. Urea may be added to eliminate the nitrous acid, it being then possible to obtain satisfactory deposits, but it is preferable to electrolyse solutions of ores containing only Cu and Fe in the presence of sulphuric acid only. The deposition of As along with the Cu may be prevented by the presence of a sufficient quantity of nitrate ions. With 100 c.cm. of solution containing 2 c.cm. of concentrated sulphuric acid and 50 mgm. of As, 5 gm. of ammonium nitrate effectually prevent the deposition of As. Under similar conditions 1 c.cm. of concentrated nitric acid prevents the separation of As from a solution containing 10 mgm. of the latter. The presence of either Zn or Al to the extent of 0·4 gm. has but little effect on the time needed for the complete deposition of Cu. Lead should be separated as the sulphate before Cu is deposited. The above results are finally used to indicate the methods which should be employed in the analysis of pyritiferous ores. T. S. P.

180. *Rapid Determination of Copper, Silver, Cadmium, and Bismuth by means of the Mercury Kathode and Stationary Anode.* **R. C. Benner.** (Amer. Chem. Soc., Journ. 32. pp. 1231–1237, Oct., 1910.)—[See Abstract No. 757 (1909).] The author uses an apparatus similar to that described by Kollock and Smith, except that the anode is stationary and not rotated. The current density at the mercury kathode is from 35–40 amps./cm.^{2}, and the stirring of the electrolyte is effected by the vigorous evolution of gas. In order to avoid all danger of loss because of this vigorous evolution of gas, the electrode vessels were somewhat taller than those used by Kollock and Smith. After deposition was complete the mercury was washed with distilled water until the current dropped to zero. The current connections were then broken, and the anode was examined for small globules of Hg by means of a magnifying glass, since this metal was frequently carried mechanically to the anode. It could usually be removed by rinsing the anode up and down in the water above the Hg. The amalgam was then washed and dried in the usual manner. 0·3888 gm. of Cu could be deposited in 20 min. from 20 c.cm. of a solution of the nitrate containing four drops of concentrated nitric acid (throughout the paper the value of a "drop" of acid is not stated), using a current of 4 amps. Quantitative results were obtained for the same solution when no free nitric acid was present, or when 4 drops of sulphuric acid were added. Using a current of 4 amps., 0·2862 gm. of Ag were deposited from 20 c.cm. of a solution of the nitrate, containing 1 drop of nitric acid, in 10 min. From 20 c.cm. of a solution of cadmium sulphate containing 5 drops of concentrated sulphuric acid, 0·5748 gm. of Cd could be quantitatively deposited in 10 min., using 4 amps. From 20 c.cm. of a solution of bismuth nitrate containing 1·2 c.cm. of concentrated nitric acid, 0·465 gm. of Bi was quantitatively deposited in 25 min., using 4 amps. During the electrolysis some peroxide forms on the anode, but it disappears before the determination is complete. T. S. P.

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181. *Relation of Osmotic Pressure to Intrinsic Pressure of Liquids.* **M. M. Garver.** (Journ. Phys. Chem. 14. pp. 651–664, Oct., 1910.)—Emphasis is laid on the fact that the energy of osmotic pressure is derived from the solvent and not in any direct way from the solute, which acts merely by depressing the activity of the liquid in which it is dissolved. T. M. L.

182. *Recent Investigations on Case Hardening.* **S. A. Grayson.** (Iron and Steel Inst., Journ. 81. pp. 287–302; Communications, p. 303, 1910. Mech. Eng. 25. pp. 583–587, May 13, 1910. Engineering, 89. pp. 791–793, June 17, 1910.)

183. *Ternary Alloys of Copper, Antimony, and Bismuth.* **N. Parravano** and **E. Viviani.** (Accad. Lincei, Atti, 19. pp. 243–247, Sept. 4, 1910.)—A continuation of the author's previous work on this subject [see Abstract No. 1541 (1910)], the position of nearly 100 alloys of Bi, Sb, and Cu_3Sb or Cu_2Sb being mapped in an equilateral triangle. Microphotographs of some of the alloys, which fully confirm the deductions made from thermal analysis, are reproduced. W. H. Si.

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1911.

CONTENTS.

GENERAL PHYSICS.

PAGE
184. New Impact Testing Machine. *R. D. MacLachlan* 65
185. Thermodynamics of Material during Change of Shape. *R. Plank* 66
186. An Aerodynamical Problem. *L. Orlando* 66
187. Inversion of the "Magnus" Effect. *M. A. Lafay* 67
188. Intensity of Periodic Fields of Force. *A. Stephenson* 67
189. Seismic Activity in Yun-nan District in 1909. *J. Deprat* 67
190. Quasi-elastic Forces due to Brownian Motions. *O. M. Corbino* 67
191. Seiches in Suwa Lake, Japan. *A. Tanaka & S. Nakamura* 68
192. Colour of the Sky. *E. Bauer & M. Moulin* 68
193. Extra Telluric Solar Radiation. *F. W. Very* 68
194. Spectrum of Chromosphere. *W. S. Adams & H. G. Gale* 69
195. Motion of Particles in Tail of Halley's Comet. *E. E. Barnard* 69
196. Perturbation of Neptune. *W. H. Pickering* 69
197. Photographs of Mars. *P. Lowell* 69
198. Water-vapour on Mars. *F. W. Very* 69
199. Bright Projection on Saturn. *M. Maggini* 70
200. Brightness of Halley's Comet. *J. Stebbins* 70
201. Photographic Observations of Meteor. *Sykora* 70
202. Stellar Parallax Determination. *C. Nordmann* 70
203. Brightness of Stars with Selenium Photometer. *J. Stebbins* 70
204. Photographing Stellar Spectra. *J. S. Plaskett* 71
205. Errors of Radial Velocity Determinations. *J. S. Plaskett* 71
206. Spectra of Close Double Stars. *A. J. Cannon* 71
207. Systematic Motions of Boss's Catalogue Stars. *A. S. Eddington* 71
208. Photographs of Nebulæ. *G. W. Ritchey* 72

PAGE
209. Stellar Radial Velocities. *W. W. Campbell* 72
210. Spectra of Sirius Procyon, and Arcturus. *W. S. Adams* 72
211. Order of Stellar Evolution. *H. N. Russell* 73
212–216. References. 73

LIGHT.

217. Apparatus for Production of Polarised Light. *A. E. Oxley* 74
218. New Form of Half Shade. *A. E. Oxley* 74
219. New Sixteen-inch Photographic Doublet. *J. H. Metcalf* 74
220. Isolation of Long Heat Waves. *H. Rubens & R. W. Wood* 74
221. Improvements of Binocular Microscope. *C. Cépède* 75
222. The Photographic Plate. *W. D. Bancroft* 75
223. Photography by Invisible Rays. *R. W. Wood* 76
224. Electron Theory of Optical Properties of Metals. *H. A. Wilson* 76
225. Determining Optical Constants of Metals. *L. R. Ingersoll & J. T. Littleton, Jr.* 77
226. Liquid Crystals in Convergent Light. *C. Mauguin* 78
227. Magnetic Birefraction of Nitrobenzene. *A. Cotton & H. Mouton* 78
228. Fresnel's Diffraction Phenomena with Grating. *H. Weisel* 78
229. Photographic Photometry. *E. S. King* 78
230. Monochromatic Illumination for Spectra-photometers. *A. Callier* 79
231. Number of Centres of Light Emission. *J. Stark* 79
232. Groove form of Diffraction Gratings. *A. Trowbridge & R. W. Wood* 79
233. Infra-red Investigations with Echelette Grating. *A. Trowbridge & R. W. Wood* 80
234. Polarised Phosphorescence. *J. Becquerel* 80
235. Phosphorescence. *L. Bruninghaus* 81
236. Phosphorescence. *W. E. Pauli* 81
237. Studies in Luminescence. XIV. Experiments on Fluorescence Absorption. *E. L. Nichols & E. Merritt* 81
238. Speed of Röntgen Rays. *E. Marx* 82
239. Deflection of RaB on Recoil from RaA. *S. Russ & W. Makower* 82
240. Heterogeneity of β-Rays from RaE. *J. A. Gray & W. Wilson* 82
241. The Period of Ionium. *F. Soddy* 82
242. Radio-active Equilibrium in Vesuvian Cotunnite. *P. Rossi* 83
243–247. References 83

HEAT.

248. Specific Heats by Explosion Experiments. II. *M. Pier* 84
249. Some Calorimetric Methods. *W. P. White* 84
250. Lag Effects and other Errors in Calorimetry. *W. P. White* 84

PAGE
251. Laws of Radiation. *E. Baisch* 85
252. Mechanical Bases of Thermodynamics. *P. Hertz* 85
253. Increase of Entropy. *H. Happel* 85
254. Reference 85

ELECTRICITY AND MAGNETISM.

255. Electricity from Falling Drops of Water. *A. Schmauss* 86
256. Electrical Conductivity of Salt Vapours. *G. C. Schmidt* 86
257. Diffusion of Gaseous Ions. *E. Salles* 87
258. Positive Thermions from Alkali Sulphates. *O. W. Richardson* 87
259. Initial Velocity of Electrons. *O. v. Baeyer & A. Gehrts* 87
260. Photoelectric Effect of Incident Light. *O. Stuhlmann, Jr.* 88
261. Formation of Kathode Rays. *L. Dunoyer* 88
262. Photoelectric Fatigue of Metals. *H. S. Allen* 88
263. Glow Discharge in Rubidium Vapour. *G. Gehlhoff* 89
264. Coloured Layers formed by Electric Discharges. *J. Elster & H. Geitel* ... 89
265. Discharge Potential in the Magnetic Field. *Gouy* 89
266. Ionisation in "Aureole" from a Mercury Lamp. *W. Matthies* 90
267. Alternate-current Arc Experiments. *G. Jäger* 90
268. Action of Condenser in Induction Coil. *J. W. Waghorn* 90
269. Electrical Properties of Selenium. III. *L. S. McDowell* 90
270. Metallic Conduction of Electricity. *Bædeker* 91
271. The Thomson-effect in Iron. *A. Aalderink* 91
272. Demonstration of the Thomson-effect. *W. König* 91
273. E.M.F. of Weston Cell. *H. Haga & J. Boerema* 92
274. Mutual Inductance of Two Coaxial Circles. *F. W. Grover* 92
275. Absolute Measurements of Large Currents. *M. Chopin* 92
276. Villari-effect in Varying Magnetic Field. *G. Ercolini* 92
277. Magnetic Shielding in Iron Amalgam. *L. Stjepanek* 93
278. Magnetic Hysteresis at Liquid-air Temperature. *R. Beattie & H. Gerrard* 93
279. Mechanical Stress and Magnetisation of Nickel. *W. Brown* 94
280. Inductance for Alternating Current of a Circuit enclosing Iron. *O. Bonazzi* 94
281. Magnetic Hysteresis. *J. A. Ewing* 94
282–289. References 94

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

290. Electrochemical Behaviour of Cobalt. *R. Schildbach* 96
291. Estimation of Chlorine in Hydrochloric Acid. *J. S. Goldbaum & E. F. Smith* 96
292. Reference 96

AUTHORS' INDEX.

Aalderink, A., 271.
Adams, W. S., 194, 210.
Allen, H. S., 262.
Bædeker, 270.
v. Baeyer, O., 259.
Baisch, E., 251.
Bancroft, W. D., 222.
Barnard, E. E., 195.
Bauer, E., 192.
Beattie, R., 278.
Becquerel, J., 234.
Boerema, J., 273.
Bonazzi, O., 280.
Bone, W. A., 254.
Brown, W., 279.
Bruninghaus, L., 235.
Buisson, H., 247.
Callier, A., 230.
Campbell, W. W., 209.
Cannon, A. J., 206.
Cépède, C., 221.
Chopin, M., 275.
Corbino, O. M., 190.
Cotton, A., 227.
Deprat, J., 189.
Dowse, C. M., 284.
Dunoyer, L., 261.
Eddington, A. S., 207.
Ehrenhaft, F., 281.
Elster, J., 264.
Ercolini, G., 276.
Ewing, J. A., 281.
Fabry, C., 247.
Fleming, J. A., 285.
Gale, H. G., 194.
Gehlhoff, G., 263.
Gehrts, A., 259.
Geitel, H., 264.
Gerrard, H., 278.
Goldbaum, J. S., 291.
Gouy, 265.
Gray, J. A., 240.
Grover, F. W., 274.
Haga, H., 273.
Happel, H., 253.
Hering, C., 288.
Hertz, P., 252.
Ingersoll, L. R., 225.
Jäger, G., 267.
Jones, H. C., 292.
Jordan, F. C., 216.
Kaluza, P., 214.
King, E. S., 229.
Koch, P. P., 231.
König, W., 272.
Kruss, H., 244.
Lafay, M. A., 187.
Littleton, J. T., Jr., 225.
Lorenz, H., 212.
Löwe, F., 243.
Lowell, P., 197.
Löwy, R., 213.
McDowell, L. S., 269.
MacLachlan, R. D., 184.
Maggini, M., 199.
Makower, W., 239.
Marx, E., 238.
Matthies, W., 266.
Mauguin, C., 266.
Merritt, E., 237.
Metcalf, J. H., 219.
Moulin, M., 192.
Mouton, H., 227.
Nakamura, S., 191.
Nichols, E. L., 237.
Nicholson, J. W., 282.
Nipher, F. E., 283.
Nordmann, C., 202.
Orlando, L., 186.
Oxley, A. E., 217, 218.
Pauli, W. E., 236.
Pickering, W. H., 196.
Pier, M., 248.
Plank, R., 185.
Plaskett, J. S., 204, 205.
Poincaré, H., 287.
Richardson, O. W., 258.
Ritchey, G. W., 208.
Rossi, P., 242.
Rubeno, H., 220.
Russ, S., 239.
Russell, H. N., 211.
Salles, E., 257.
Schildbach, R., 290.
Schlesinger, F., 215.
Schmauss, A., 255.
Schmidt, G. C., 256.
Sirk, H., 245.
Smith, E. F., 291.
Soddy, F., 241.
Stark, J., 231.
Stebbins, J., 200, 203.
Stephenson, A., 188, 246.
Stjepanek, L., 277.
Stuhlmann, Jr., O., 260.
Sykora, 201.
Tanaka, A., 191.
Trowbridge, A., 232, 233.
Very, F. W., 193, 198.
Waghorn, J. W., 268.
Weisel, H., 228.
West, A. P., 292.
White, W. P., 249, 250.
Wilson, H. A., 224.
Wilson, W., 240.
Wood, R. W., 220, 223, 232, 233.
Zahn, H., 289.